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SOIL SURVEY

OF

KEWAUNEE COUNTY

WISCONSIN

BY
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OF THE
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INTRODUCTION

Before the greatest success in agriculture can be reached, it is necessary that the farmer should have a thorough knowledge of the soil upon his own farm. A soil may be well adapted to one crop, and poorly adapted to another crop. Clover will produce a vigorous growth and profitable yields on the average loam soil which contains lime and is in a sweet condition; but on a sandy soil which is sour, or in an acid condition, clover will not make a satisfactory growth. We may say, therefore, that failure is certain to be invited when such important facts are disregarded, or overlooked. The degree of success which it is possible to win on any farm is in direct proportion to the practical knowledge possessed by the farmer concerning the soil and its adaptation to crops. A thorough knowledge of the soil is as essential to the farmer as a knowledge of merchandise and business methods is to the merchant.

The State of Wisconsin, working in coöperation with the United States Department of Agriculture, is making a careful study of soils and agricultural conditions throughout Wisconsin the State. A soil map shows the location and extent of the different kinds of soil. Tracts of 10 acres and over are mapped, but often areas of even smaller extent are shown. The soil map is prepared by trained men, who go over a county thoroughly, and examine the soil by making a sufficient number of borings to a depth of 36 inches to keep account of all variations. A report is also made, to accompany and explain the map, and this is based upon a careful study of the soils within the region surveyed, and upon such other features as have a direct bearing upon the agriculture of the area.

It is the object of this survey to make an inventory of the soils of the State, and to be of practical help to farmers by lo-

cating and describing the different soils, by determining their physical character and chemical composition, and by offering suggestions for their management, based upon the work of the Soil Survey within the area, covered in the report, and upon the results of field tests made by the Experiment Station.

Soil fertility depends upon two factors: first, upon the physical characteristics of the soil, such as water holding capacity, workability, etc., and second, upon the chemical composition of the material composing the soil. The chemical composition depends upon the mode of origin of the soil, and the source of material from which the soil is derived.

Water holding capacity, and other physical properties of soil all depend chiefly upon *texture*, which refers to the size of the individual soil grains, or particles. A coarse sandy soil, for example, will not retain moisture so long as a loam soil, or clay loam, because the finer the soil grains, the greater will be the total soil-grain surface area to which moisture may adhere. Texture is determined in the field by rubbing the soil between the thumb and fingers, and with experience one soon beomes expert at judging the size of soil grains. This field judgment is verified in the laboratory by a *mechanical analysis*, which is made by a simple method of separating soil grains into different groups, of which there are seven. These are known as clay, silt, very fine sand, fine sand, medium sand, coarse sand, and fine gravel.

A chemical analysis is also made of the soil to determine the amounts of various essential plant-food elements which are present. A chemical analysis shows whether the soil contains a large store of plant food, or only a small quantity, and it indicates which kinds of plant food will probably be needed first. The amount of organic matter in the soil is also determined, and tests are made to show conditions relative to soil acidity.

SOIL CLASSIFICATION.

Soils are grouped according to texture into soil classes, a *soil class* being made up of soils having the same texture, though differing in other respects. A fine sand, for example, may be light colored and of alluvial origin, while another fine sand may be dark in color and of residual origin, while a third fine sand may have been blown into sand dumes by the wind, yet all of these soils would belong to the same class, because the greater proportion of the soil grains have the same size or texture. Thus we may have different kinds of clays, loams, sands, etc., and the class to which any soil will belong depends upon the size of the individual soil grains of which it is composed, and not upon its color, origin, topographic position, or agricultural value.

SOIL CLASSES

Soils Containing Less Than 20% Silt and Clay

Coarse sand.—Over 25% fine gravel and coarse sand, and less than 50% of any other grade of sand.
Sand.—Over 25% fine gravel, coarse and medium sand, and less than 50% fine sand.
Fine sand.—Over 50% fine sand, or less than 25% fine gravel, coarse and medium sand.
Very fine sand.—Over 50% very fine sand.

Soils Containing Between 20–50% of Silt and Clay

Sandy loam.—Over 25% fine gravel, coarse and medium sand.
Fine sandy loam.—Over 50% fine sand, or less than 25% fine gravel, coarse and medium sand.
Sandy clay.—Less than 20% silt.

Soils Containing over 50% of Silt and Clay

Loam.—Less than 20% clay, and less than 50% silt.
Silt loam.—Less than 20% clay, and over 50% silt.
Clay loam.—Between 20 and 30% clay, and less than 50% silt.
Silty clay loam.—Between 20 and 30% clay, and over 50% silt.
Clay.—Over 30% clay.

Soils may be grouped in another way. Where soils are closely related through similar sources of the material from which derived, mode of origin, topographic position, etc., so that the different soils constitute merely a graduation in texture of otherwise uniform material, such a group is called a *soil series*. It corresponds to the family which is made up of different in-

dividuals having the same parentage. The Miami series, for examples, includes light colored, glacial material where the soils have been derived largely from the underlying limestone, and the soils in the series range in texture from a clay loam to sand and gravel. The Plainfield series includes light colored soils in regions where no limestone is present, where the present rock was largely sandstone, and where the material occurs as outwash plains or stream terraces. The soils in this series also have a wide range in texture. The name used for a soil series usually indicates the locality where that particular series was first recognized and mapped by the Soil Survey.

By uniting the name of the *soil class*, which refers to texture, with the name of the *soil series*, which refers chiefly to origin, we get the *soil type*, which is the basis or unit of classifying and mapping soils. A *soil type*, thus, is a soil which is uniform throughout its entire extent and texture, color, topographic position, and other physical properties, and having a distinct agricultural unity, that is, being adapted to the same crops, and requiring the same treatment. It is also uniform in the source of material from which it is derived, and the mode of origin which, taken together, determine the chemical composition. Since the soil type is the unit in classifying and mapping soils, and the basis upon which experimental work should be conducted, every farmer should be familiar with the soil types on his farm, and their leading characteristics.

SOIL SURVEY OF KEWAUNEE COUNTY, WISCONSIN.

CHAPTER I.

GENERAL DESCRIPTION OF THE AREA.

Kewaunee County is located in the eastern part of Wisconsin. It is bounded on the north by Door County, on the east by Lake Michigan, on the south by Manitowoc County, and on the west by Brown County. The northwestern corner of the county is bounded by Green Bay for a distance of about 3 miles. The county is 24 miles long from north to south, and its greatest width is about 18 miles. It comprises an area of approximately 341 square miles, or 218,240 acres.

The most pronounced topographic feature of the county consists of what is known as the Kettle Moraine, the main portion of which begins near the center of Casco Township and extends south, gradually becoming wider until it covers nearly half of West Kewaunee, half of Montpelier, half of Carlton, and the greater part of Franklin Townships. This region represents the medial moraine formed between the Green Bay and Lake Michigan glaciers. Its surface varies from level to rolling and hilly, the level tracts being much more limited in extent than the rougher areas. The topography of this section is truly glacial in character, and pot holes, small swampy areas, and stony and gravelly regions are common. Several other portions of the county also have a glacial topography, although these are of much smaller extent than the one described above. The western part of Lincoln Township and the eastern part of Red River

Township exhibit glacial action, and the surface is rolling over most of this section. Stone and bowlders are very plentiful over a part of the region. Another morainic belt is found to the southwest from Algoma, where the surface is quite hilly and kettle holes and small marshes are numerous. The remainder of the county is undulating to gently rolling. Some nearly level areas are found in Carlton, West Kewaunee, Luxemburg, and Red River Townships and in a few other sections. The streams throughout the county have cut deep channels through the soil-forming material, and along the Kewaunee River and some of the smaller streams numerous ravines are found branching off from the main stream valley. The height from the stream bed to the level of the surrounding country ranges from 10 to nearly 100 feet. There are also a number of ravines running back from the shore of Lake Michigan. The bluffs along the Lake range in elevation from 50 to about 100 feet above the level of the Lake, and the county as a whole probably averages from 100 to 150 feet above the Lake level.

The Kewaunee River, with its several tributaries, forms the chief drainage course of the county. It heads in the eastern part of Brown County and traverses the area surveyed, passing through Luxemburg, Casco, and West Kewaunee Townships and flowing into Lake Michigan at the city of Kewaunee. The Ahnapee River crosses the northeastern corner of the county, drains most of the Ahnapee and Lincoln Townships, and flows into Lake Michigan at Algoma. A number of small streams a mile or so in length empty into the Lake. The drainage of the southern part of the county is chiefly through East Twin River and Black Creek southward through Manitowoc County into the Lake. A very small part of the northwestern corner of the county drains into Green Bay.

The first settlement in the county was made at Kewaunee in 1837. The county was organized in 1856, after which the population increased quite rapidly. Some of the first settlers came from Manitowoc County and some from neighboring States, though a large proportion came directly from foreign countries. Lincoln and Red River Townships were first settled chiefly by Belgians, Luxemburg by Germans, West Kewaunee by Poles,

and Carlton by Norwegians. Other nationalities are represented in the area, but not to so great an extent as those mentioned. All of the settlements grew, and at present all portions of the county are well populated.

Kewaunee, the county seat, has a population of 2,100 and is an enterprising city. It has a canning factory, planing mill, furniture factory, an aluminum factory, an electric-light plant, two breweries, a creamery, and a number of other industries, besides being the shipping point and distributing center for a large section. Algoma, a city of 2,250 inhabitants, is situated on the lake in the northern part of the county. It has canning, furniture, sash and door, lace, and fly-net factories, a planing mill, foundry, creamery, and other industries. There is a good farming country tributary to this point, and to the north the fruit industry is beginning to develop. Luxemburg and Casco are smaller towns, located on the railroad and surrounded by good farming country. Rio Creek and Clyde are also railroad shipping points. A large number of small villages are scattered throughout the county.

The Kewaunee, Green Bay & Western Railroad, which crosses the State from west to east from Winona, Minn., passing through Independence, Waterbury, Grand Rapids, Green Bay, and other points, traverses the area surveyed, touching Luxemburg, Casco Junction, and Clyde, and terminates at Kewaunee. Two freight ferries cross Lake Michigan from Kewaunee, connecting with the Ann Arbor Railroad at Frankfort, Mich., and with the Pere Marquette at Ludington, Mich. From Casco Junction a branch, called the Ahnapee & Western Railway, runs through Algoma and on to Sturgeon Bay in Door County. The main lines of steamers plying the lakes make regular stops at Kewaunee and Algoma and give this region direct water connection with Chicago, about 200 miles by water from Kewaunee, and with Milwaukee and other lake ports.

The cities and towns within the county furnish a market for considerable farm produce. Kewaunee, Algoma, and Luxemburg, with the other railroad points, provide shipping facilities for all produce sent to more distant markets. Green Bay is but 37 miles from Kewaunee by rail, from which point the Chicago &

North Western and the Chicago, Milwaukee & St. Paul Railroads furnish excellent shipping facilities to the leading markets of the Middle West.

The main wagon roads of the area are graded up, and many of them are crowned with gravel and kept in good condition. Throughout the clay loam region the soil is heavy, and where special attention is not given to grading and keeping up the highways, travel over them becomes very difficult during wet seasons. Gravel beds are so numerous that this material can be readily obtained for road building in nearly all parts of the county. Where gravel is not available, limestone could often be secured and crushed if the proper machinery were at hand.

Rural free delivery routes reach practically all parts of the county, and telephones have been installed in many homes. The telephone, however, is not in as common use in the country districts of this county as in those in many other parts of Wisconsin.

SOILS.

The soils of Kewaunee County have been derived from glacial material and from lacustrine, or lake laid material. The underlying rock consists of Niagara limestone, and this has contributed to a considerable extent in the formation of much of the soil material. The lacustrine deposits, which consist largely of red clay, were probably laid down during an inter-glacial period. During the advance and retreat of the Late Wisconsin Ice Sheet large quantities of this lake laid material were picked up by the ice, mixed with other glacial debris, transported varying distances by the ice and again deposited in the form of glacial drift. The movement of the ice scraping over the limestone ground off quantities of this rock so that the greater proportion of the gravel in this region consists of limestone, and doubtless much of the finer material forming the soil was also derived from this source. The red lacustrine drift seems to have been carried in the lower portion of the glacial ice sheet and was deposited chiefly as ground moraine, while the material carried in the upper portion of the ice sheet was light colored, and was deposited chiefly as a morainal ridge lying north and south

along the central axis of the county, narrow at the north end, but widening southward. Streams issuing from beneath the ice deposited considerable material in the form of outwash plains. Since the retreat of the ice sheet a small amount of material has been transported by water action and deposited in the valley of present day streams. In low, poorly drained places there has been an accumulation of decaying vegetable matter so that the soils in such places have been completely covered by material widely different from the glacial debris. It will thus be seen that the material covering the surface of this area has a wide variation. In the Soil Survey this material has been classified into 8 soil series and 20 soil types.* Each series and each type has certain definite characteristics by which it can be recognized.

The Superior series includes those soils which have a red or pinkish-red subsoil, and which were formed largely from lake laid material worked over by ice action. This is the most extensive series in the county, and it includes a large amount of excellent agricultural land. The types mapped as belonging to this series are Superior clay loam, Superior clay loam, rolling phase, Superior loam, rolling phase, and Superior fine sandy loam, rolling phase.

The Miami series includes the light colored, upland, timbered soils in the glaciated limestone region where the material occurs as unassorted glacial drift. This series is not as extensive in Kewaunee County as the Superior series, but it includes excellent farming land and it is one of the most important series of soils in the State. Miami loam is the only type mapped in this area as belonging to the Miami series.

The Fox series consists of the light-colored glacial material

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* The Superior clay loam as described in this report includes what was originally mapped by the Bureau of Soils as Superior clay loam, till phase.

The Superior clay loam, rolling phase, includes what was previously mapped as Kewaunee clay loam.

The Superior loam, rolling phase, includes what was previously mapped as Kewaunee loam.

The Superior fine sandy loam, rolling phase, includes what was originally mapped as Kewaunee fine sandy loam.

Plainfield gravelly sandy loam includes what was first mapped by the Bureau of Soils as Fox gravelly sandy loam.

Plainfield sand includes what was originally mapped as Fox sand.

which has been modified or transported by the action of water and deposited as overwash plains or as valley fill. Four types of this series—the Fox silt loam, sandy loam, gravelly sandy loam, and sand—were mapped.

The light-colored glacial material which was deposited by water beneath the ice sheet and which is now found as morainic material, kames, and eskers, has a lower agricultural value than typical glacial till soils, since it is droughty, has a rolling surface, and a low content of organic matter. Such material has been included in the Rodman series and five distinct types were mapped—the Rodman gravelly loam, gravelly sandy loam, sandy loam, fine sand, and gravel.

The Poygan series is of very limited extent. It represents lacustrine material, the position of which has favored the growth and decay of vegetable matter to such an extent that the large amount of organic matter present imparts a black color to the soil. The subsoil is similar to the subsoil of the Superior soils. Two types belonging to the Poygan series were mapped, the Poygan silt loam and sand.

The Clyde series represents old lake beds and low, swampy tracts in which there is an accumulation of vegetable matter, but not in sufficient quantities to form Peat or Muck. The soils are black and very high in the content of organic matter. The Clyde silt loam is the only type recognized as belonging to this series.

The Genesee series includes light-colored alluvial soils in the glacial and lacustrine region and is represented in this area by two types, the Genesee loam and fine sandy loam.

The Dunkirk series represents old terraces bordering glacial lakes and is developed only to a very limited extent in the present survey. Only one type, the Dunkirk sand, was mapped.

The large accumulation of vegetable matter in varying stages of decomposition has been classed as Peat.

Such conditions as rock outcrop, gravelly or stony areas, steep slopes, and swampy areas in the various soil types have been indicated on the soil map by appropriate symbols.

The name and extent of each soil mapped in the county is given in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.
Superior clay loam	7,616	47.2
Superior clay loam, rolling phase	95,499	
Superior loam, rolling phase	30,912	14.2
Miami loam	24,128	11.1
Peat	19,328	8.8
Clyde silt loam	9,920	4.5
Fox silt loam	6,208	2.8
Plainfield gravelly sandy loam	3,328	1.5
Rodman sandy loam	3,072	1.4
Genesee loam	2,432	1.1
Plainfield sand	2,368	1.1
Rodman gravelly loam	2,304	1.1
Superior fine sandy loam, rolling phase	2,112	1.0
Fox sandy loam	2,048	.9
Rodman gravelly sandy loam	1,792	.8
Genesee fine sandy loam	1,664	.8
Rodman gravel	1,088	.5
Rodman fine sand	1,024	.5
Dunkirk sand	960	.4
Poygan silt loam	384	.2
Poygan sand	64	.1
Total	218,240	.....

CHAPTER II.

GROUP OF HEAVY UPLAND SOILS.

SUPERIOR CLAY LOAM.

Description.—The surface soil of Superior clay loam, to an average depth of about 8 inches, consists of a dark-gray or grayish-brown clay loam which contains a large amount of silt and only a small amount of organic matter. When dry the surface few inches, which is the most silty, frequently has an ashen appearance. Slight mottlings of reddish-brown are common. The subsoil consists of a heavy, compact, tenacious red clay or clay loam which extends to depths greater than 3 feet. Commonly a little gravel is found on the surface and mixed with the soil and subsoil and finely broken rock fragments may also occur. Most of this material is of limestone. A very few bowlders occur upon the surface, but these are never present in sufficient numbers to interfere with the cultivation of the soil. They will average less than one to the acre.

There is one very important variation in the Superior clay loam, and this has been separated from the typical soil on the basis of topography and the resulting differences in agricultural value, and is indicated on the soil map by means of cross lines placed over the color representing Superior clay loam. This rolling phase is discussed as a separate type following the description of the typical soil.

Extent and distribution.—The type covers an area of approximately 12 square miles and is confined to West Kewaunee and Carlton Townships. The surface is level to very gently undulating and the natural surface and under-drainage deficient. In texture and structure the type very closely resembles the rolling phase, though it may be a little heavier. It differs from

VIEW SHOWING TYPICAL LEVEL SURFACE OF SUPERIOR CLAY LOAM.

This is a good general farming soil, well adapted to production of grasses and to dairying. The level surface and heavy soil makes the surface drainage deficient. Tile drains would be

that type chiefly in topography and the resulting differences in drainage and agricultural value. It is surrounded by the rolling phase of Superior clay loam, and the line of separation is often an arbitrary one.

Topography and drainage.—Superior clay loam, occupies a plain slightly more than 100 feet above the level of Lake Michigan, into which the streams and ravines leading to the lakes have not as yet cut their way. In time the entire type will doubtless be dissected by erosion channels and the surface features changed to be the same as the rolling phase. At present the surface is dotted with numerous slight depressions in which water stands in the spring and after heavy rains. The differences in elevation between the lowest portion of the depressions and the higher land intervening varies from 2 to 6 feet, with an average of about 3 feet. On an acre there may be four or five such depressions. Some have an outlet leading into the adjoining one, though quite a few have no outlet and are doubtless pot holes.

Origin.—The material composing Superior clay loam, is of lacustrine origin, but since its first deposition it has been modified by glacial action, though the evidences of such action are not nearly as plentiful on this type as on Superior clay loam, rolling phase. The subsoil is quite calcareous, but the surface has been leached, and but little if any lime carbonate remains in the surface soil.

Native vegetation.—The original timber growth consisted of white pine and hardwoods. In some places the growth was chiefly pine, while in others maple and beech predominated. Very nearly all the timber has been removed and the land put under cultivation. What woodlots remain have had the best timber removed.

Present agricultural development.—By far the greater proportion of the type is under cultivation. While it is naturally a strong soil it is not as highly improved as might be expected in a section which has been settled as long as this. The chief crops grown are oats, barley, wheat, rye, corn, clover, and timothy. Because of deficient drainage the yields are variable, and on some of the depressed areas crops are often a failure. On ac-

count of the short season corn is not extensively grown, but some of the improved varieties can usually be depended upon to mature. As dairying is the leading branch of farming practiced the corn can be preserved in the silo, even though it does not fully mature. Oats yield from 20 to 40 bushels, barley from 20 to 30 bushels, wheat 10 to 18 bushels, rye from 15 to 18 bushels, and hay from 1½ to 2 tons per acre. The hay crop consists of clover anl timothy mixed, or very often of timothy alone. It seems difficult to get and keep a stand of clover. The yields on the typical soil will average somewhat lower than on the rolling phase, because of the poorer drainage. During dry seasons the yields will frequently be higher than those indicated, and equal to those from the rolling phase, but very frequently the heavy rains of spring keep the ground wet and cold until late in the season, and summer rains often keep the small depressions wet so that fields have a spotted appearance. Frequently 20 to 25 percent of a field will produce nothing on account of these conditions. This soil is difficult to cultivate and great care must be exercised in plowing and all subsequent cultural operations. The best results are obtained when the land is plowed in the fall, but this is not always possible. But few tile drains are in use.

The only special crop raised to any extent on this soil is peas. Where the drainage is fair this crop does very well. Irish potatoes are grown for home use, but the soil is too heavy for potato growing on a commercial scale.*

SUPERIOR CLAY LOAM, ROLLING PHASE.

Description.—The surface soil of Superior clay loam rolling phase, consists of a grayish-brown clay loam, averaging 8 inches in depth, which contains a large amount of silt and only a comparatively small amount of organic matter. On drying out the surface material has an ashen-gray appearance and slight mottlings of reddish-brown are common. Gravel stones less than one-half inch in diameter are frequently found throughout the soil and subsoil, usually in small amounts, although the quantity is vari-

*For methods of improvement of this soil see page 32.

able. Most of the gravel is limestone, but granite, quartz, and other rocks foreign to the region are also represented. The subsoil consists of a heavy, compact red clay loam or clay which extends to a depth of over 3 feet. The material is stiff and tenacious where typically developed, but contains small angular fragments of limestone, which are frequently so thoroughly disintegrated that they can be easily crushed. This finely broken rock, when plentiful, imparts a gritty feel and gives the subsoil a looser structure. Over a portion of the type a few bowlders occur on the surface. The type as a whole, however, is comparatively free from bowlders.

Superior clay loam, rolling phase, in Kewaunee County differs somewhat from the type as found along the shore of Lake Superior, chiefly in containing more gravel, being less uniform throughout its occurrence, and, as a whole, a little lighter in texture. The variations are due largely to glacial action, which influenced this type to a greater extent here than in other parts of Wisconsin. While some of the variations are quite distinct, none of them are of sufficient extent or importance to be mapped separately.

The depth and color of the surface soil are variable. Where the surface is bumpy the soil is deeper and darker in the depressions than typical, while on the bumps or knolls the heavy red-clay subsoil is frequently exposed. In the western part of the county the depth to rock averages about 15 feet, which is less than in the eastern portion, and outcrops are frequently seen. In Montpelier and Franklin Townships and in a number of other places, where this type borders the morainic region, the type is itself somewhat morainic and the soil frequently contains small accumulations of sand and gravel. This material may occur as beds beneath the red clay subsoil within reach of the auger or the sand may be found at the surface—sometimes overlying the red clay. The region extending for several miles southwest from Algoma is quite morainic, containing a number of pot holes and small marshes and carrying considerable gravel in the subsoil. For a distance of 1 to 1½ miles immediately along the shore of Lake Superior the type is usually lighter in texture than is the

case farther back, and pockets and small areas of sand are frequently found.

Extent and distribution.—This soil is the most extensive and important type in Kewaunee County and occupies approximately half of the area surveyed. It occurs as a belt along Lake Michigan, extending from the southern boundary of the county northward to near Algoma, where it grades into the Kewaunee loam. This type is also extensively developed in the western and northwestern parts of the county covering the greater part of Red River, most of Luxemburg, nearly half of Montpelier, and a small part of Franklin Townships.

Topography and drainage.—The surface of the type varies from undulating to rough and broken. The roughest sections are found along the Kewaunee River and its tributaries, where erosion has been more active than elsewhere. For one-fourth to three-fourths of a mile on both sides of the streams bordering the narrow bottom land the surface has frequently been deeply cut by ravines and rendered unfit for cultivated crops. Along the shore of the lake there are also numerous ravines. The total area of such land, however, is comparatively small. To the southeast of Rankin the type has a morainic character, and is quite rough and broken, as is also the case, though to a lesser extent, in places where it borders the Kettle Moraine. The greater part of the type is level to gently rolling. In Carlton and West Kewaunee Townships are tracts of similar soil of considerable size where the surface is nearly level, but on account of their poorly drained condition they have been classified with the Superior clay loam, till phase, which differs from the Kewaunee in topography and drainage and resulting variation in agricultural value.

Origin.—The rolling phase of Superior clay loam is partly of glacial, and partly of lacustrine, or lake laid, origin. In order to account for the existence of such a large amount of clay of such uniform character it is necessary to assume the existence of a body of quiet water in which it accumulated prior to the time when it was picked up by the moving ice. The ice mixed it with gravel, consisting of quartz granite and other rocks, and some bowlders. The underlying limestone was ground up to a

VIEW OF SUPERIOR CLAY LOAM, ROLLING PHASE, SHOWING CHARACTERISTIC TOPOGRAPHY.

The surface features as indicated by this view are also typical for Superior loam, rolling phase. Both types are adapted to general farming and dairying, and the fruit industry is being developed to some extent in favored localities.

considerable extent by the glacier, and small fragments of this rock and limestone gravel are now found scattered through the soil and subsoil. The surface of the soil has been thoroughly leached and most of the carbonate of lime removed, leaving the soil in many places in a slightly acid condition. The subsoil, however, is quite calcareous, the amount of calcareous matter usually increasing with depth, being especially noticeable in the section between 1 and 3 feet below the surface.

Native vegetation.—The original timber growth on this type was varied and consisted of both pine and hardwoods. White pine was the most plentiful, though a small amount of Norway pine was also present. Of the hardwoods, maple, beech, birch, basswood, and some oak, hickory, and ash were found. Hemlock, cedar, and balsam also grew in this region. Over some portions of the type pine was the only growth; in other sections the hardwoods alone were found; while again the hardwoods, pines, and hemlock formed a mixed growth. All of the merchantable timber has been removed from this soil, and where not cultivated a second growth of birch, poplar, and in places some willows are found.

Present agricultural development.—By far the greater part of this type is under cultivation, and while it is a strong soil it is not as highly improved as might be expected of a region which has been settled as long as this. The chief general farm crops grown are oats, barley, wheat, rye, corn, clover, and timothy. The yields obtained are variable, owing to the heavy retentive subsoil, which keeps the land wet until late in the spring, to the methods of cultivation, which are not always sufficiently thorough, to climatic conditions, and also to the use of grain which is often not the best obtainable for seed. Corn is not extensively grown, as the season is short, though some of the new improved varieties mature in this section and fair yields are secured. Where the silo is in use the corn is fed chiefly in the form of silage. Oats yield from 20 to 40 bushels, barley from 20 to 35 bushels, wheat from 10 to 20 bushels, rye from 15 to 20 bushels, timothy about 1½ tons, and timothy and clover mixed from 1½ to 2½ tons per acre. Considerable difficulty is experienced in getting and keeping a stand of clover, and over por-

tions of the type but little is grown. This type is difficult to cultivate and it requires heavy stock and strong tools. When plowed too wet it is apt to puddle. On the heavier places large clods are sometimes turned up, which are quite difficult to pulverize. The poorly drained sections are more difficult to handle than where the natural drainage is good, since in the depressions and draws and even on some gentle slopes the land remains in a wet, soggy condition until quite late in the spring. The best results are obtained when the land is plowed in the fall, but this is not always possible. Stable manure is applied to the type, but green manuring is not a common practice and no commercial fertilizers are used.

Among the special crops grown the pea crop is the most important. Formerly the peas were produced chiefly for the canning factories, but many of these have shut down and now most of the crop is allowed to mature. Yields range from 10 to 20 bushels per acre. In former years considerably larger yields were secured. The soil is often too wet for this crop and failures are frequently due entirely to this one cause. Irish potatoes are grown for home use and fair yields are secured, but the industry has not been developed on a commercial scale. The type* is better adapted to other crops than to potatoes.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Superior clay loams, rolling phase:

Mechanical analyses of Superior clay loam, rolling phase.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Soil	0.8	3.0	4.6	12.2	9.0	41.5	29.2
Subsoil	.5	1.6	3.3	9.1	5.7	39.3	40.4

* For methods of improvement of Superior clay loam, rolling phase, see page 32.

SUPERIOR LOAM, ROLLING PHASE.

Description.—The surface soil of this type consists of a grayish-brown loam, with an average depth of 12 inches. It contains considerable silt, a comparatively small amount of organic matter, and some coarse material in the form of ground-up rock fragments. A small amount of gravel occurs in the soil and bowlders are quite commonly found upon the surface, being very plentiful over some sections. The subsoil consists of a brownish-red clay loam, containing enough small rock fragments to impart a gritty feel to the material. Gravel is commonly found scattered through the subsoil and cobblestones and bowlders are sometimes so plentiful as to make boring very difficult. The subsoil resembles that of the type mapped elsewhere as Superior clay loam, rolling phase, but contains much more coarse material. The gravel, rock fragments, and stones consist largely of limestone, but some granite and other rocks foreign to the region are also found. The depth to the underlying limestone rock is less than that of the Superior clay loam, rolling phase, and a number of outcrops occur.

Extent and distribution.—This type is an important soil in the northern half of the county. It is the predominating type in Ahnapee and Lincoln Townships, is quite extensive in Casco, and also occurs in the eastern parts of Luxemburg and Red River Townships. It is closely associated with Superior clay loam, rolling phase, and the boundary line between them is frequently an arbitrary one.

Topography and drainage.—The surface of the type varies from gently rolling to rolling, the roughest sections being found along the stream courses. A few undulating areas are also found, but these are of comparatively small extent. The topography is of morainic character in the northwestern corner of the county, where a morainic area starts about a mile back from the lake and a mile south of the northern county line and extends to the southwest, gradually becoming wider. The surface here is somewhat bumpy, with numerous shallow kettle holes and some small marshes. Gravel beds occur in the subsoil throughout this region.

The natural drainage of the type is good, except in depressions, draws, and in some of the small marginal areas bordering marshes where the surface is nearly level. Along the border of Superior clay loam, rolling phase, the drainage is in places deficient. Tile drains could be installed to advantage over these poorly drained portions of the type. From some of the knoll tops and on some of the slopes the surface soil has been eroded and the subsoil exposed. The question of erosion, however, is not a serious one on this type, and, with only a few exceptions, the soil can be kept in place on the steepest slopes by following proper methods of cropping and cultivation.

Origin.—The origin of the Superior loam, rolling phase, consists of glacial and lacustrine material and is practically the same as that of Superior clay loam, rolling phase. The ice sheet broke up much of the underlying Niagara limestone, which formation has contributed more largely than any other to the supply of gravel and stones mixed with the soil. Granite, quartz, and some other rocks are also found, though to a much smaller extent than the limestone. The material forming the soil contains much carbonate of lime. In some places the lime has been leached out of the surface soil to a depth of a few inches, though an acid condition does not exist over any of the type. The lime content increases with depth, the subsoil containing much more than the surface soil.

Native vegetation.—The original timber growth consisted chiefly of maple, beech, and hemlock, with some white pine, Norway pine, cedar, and balsam. Practically all of the merchantable timber has been removed.

*Present agricultural development.**—The soil of this type is highly improved and by far the greater part of it is under cultivation. General farming and dairying constitute the chief lines of agriculture followed. The leading crops produced are oats, peas, barley, rye, corn, wheat, hay, and some flax. Oats are probably grown more extensively than any of the other grain crops and the yields average from 30 to 35 bushels per acre. Barley is not as important a crop as oats. Yields range from 25 to 35 bushels per acre. Corn is grown mostly for the silo, but the more hardy varieties will mature and give fair yields. Wheat

*For chemical composition and improvement of this type see page 32.

is grown to a limited extent and yields from 15 to 20 bushels per acre. Rye yields from 20 to 25 bushels per acre. Some flax is grown, especially on the low, more poorly drained areas adjoining marshes, and yields from 20 to 30 bushels per acre. This crop is considered to be hard on the land. Hay, consisting of clover and timothy or timothy alone, yields from 1½ to 2 tons per acre. Peas constitute an important special crop on this soil and most of the product goes to the canning factories. Average gross receipts range from $40 to $60 per acre. In some cases as high as $100 per acre has been received, though this is exceptional. Wet springs, with excessive hot and dry weather later in the season, sometimes cause almost complete failures. More of the crop is allowed to mature now than formerly, being sold as seed. Sugar beets are grown to a limited extent, with very fair success, and yields average from 10 to 14 tons and sometimes as high as 18 tons per acre. Potatoes are grown chiefly for home use. They are better adapted to this type than to Superior clay loam, rolling phase. Yields average about 125 bushels per acre.

Fall plowing is practiced quite extensively, though the type can be cultivated in the spring more readily than the clay loam. The drainage conditions are better than on the heavier types, and the soil warms up earlier in the spring and can be cultivated under a wider range of moisture conditions. Stable manure is the only fertilizer used to any extent. A green crop is sometimes plowed under, but the practice is not common. The question of crop rotation best suited to this soil receives but little attention, and quite a variety of rotations are followed, some of which are not adapted to existing conditions. One that is perhaps the most common and better than any of the others is as follows: One year corn or peas, followed by one year each of barley and oats, with the latter seeded to clover and timothy. Hay is cut for one or two years and the field may be pastured for a year before again plowing for corn. Manure is usually applied to the sod.

The following table shows the results of mechanical analyses of samples of the soil and subsoil of Superior loam, rolling phase:

Mechanical analyses of Superior loam, rolling phase.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Soil	2.0	4.7	8.5	20.2	13.7	41.7	8.7
Subsoil	.9	3.0	6.5	20.2	11.3	34.6	22.6

MIAMI LOAM.

Description.—The surface soil of Miami loam consists of a grayish-brown medium-textured loam, with an average depth of 10 inches. The content of organic matter is comparatively low, except in depressions, where it has accumulated owing to deficient drainage. Bowlders, mostly of limestone, frequently occur on the surface, and gravel is often found mixed with the soil. The subsoil consists of a yellowish to chocolate-brown clay loam of rather light texture, and contains a large amount of ground-up rock, principally limestone, which increases with depth and imparts a gritty feel. At from two to three feet this gritty material, together with gravel and cobblestones, is frequently quite plentiful, and over portions of the type gravel beds are encountered. In Franklin Township, where the tpye is associated with the Rodman sandy loam, large quantities of sand are mixed with the soil. This variation is most pronounced in the southern sections. North of Ellisville there is more silt in the soil than is typical, and also some fine sand. Rock outcrops occur frequently in Montpelier and Franklin Townships, though the depth to bedrock usually ranges from 6 to 10 feet or more. Where gravel beds occur beneath the soil, pockets of sand are also frequently found. The slopes and tops of knolls are sometimes eroded and the underlying subsoil exposed.

Extent and distribution.—Miami loam is confined to the southern half of the county and is the predominating type in Franklin and Montpelier Townships. It is the only soil of the Miami series in the area, and numerous small tracts of Rodman gravel, gravelly sandy loam, sandy loam, fine sand, Clyde silt loam, some

marshy areas, and also soils of the Fox series are found associated with it.

Topography and drainage.—The surface of this type varies from rolling to rather hilly, although a bumpy topography is developed over a considerable area and there are tracts of small extent where the surface is only gently undulating. On account of the surface features and the underlying gritty subsoil the natural drainage is good, except in depressions, draws, etc., where a single line of tile would usually be sufficient to carry off the excess water.

Origin.—Miami loam is of glacial origin and consists of material worked over and ground up by the ice sheets of the Lake Michigan and Green Bay Glaciers and deposited in what is known as the Kettle Moraine. It contains a considerable amount of limestone ground from the underlying rock, together with some material which is foreign to this region. Gravel and bowlders of limestone, granite, quartz, etc., are quite common on the surface and in both soil and subsoil. On account of the high content of finely ground limestone and limestone gravel, the mass of the material composing the type is calcareous. The carbonate of lime has been leached from the surface in places, however, and in some sections a slightly acid condition exists. Over a part of the type sweet clover is found growing along the roads, and in such places the soil is not acid.

Native vegetation.—The original timber growth consisted chiefly of maple and beech, some red and white oak, hickory, ironwood, and a scattering of white pine and hemlock, with some cedar in the low places. There are still quite a number of valuable woodlots on this type, and from 5 to 10 per cent of the land is in timber. The remaining timber is mostly beech and maple.

Present agricultural development.—Miami loam is a fairly good general farming soil, and by far the greater part of it is under cultivation and well improved. The type of agriculture followed consists chiefly of general farming and dairying. The crops grown are oats, barley, corn, hay, rye, peas, and a small amount of wheat. The yields obtained are fairly well represented by the following figures, though there is considerable variation from year to year: Oats, from 20 to 45 bushels; bar-

ley, 20 to 35 bushels; rye, 15 to 25 bushels; wheat, 10 to 15 bushels; and hay, 1 to 2 tons per acre. It is difficult to get a stand of clover, and the greater part of the hay is timothy. Comparatively little corn is grown to maturity. It is cut and preserved as silage. Some varieties of corn will mature, however, and fair yields are secured. Among the special crops peas are the most extensively grown. Yields of from 25 to 40 bushels per acre have been secured in former years, but at present the range is from 10 to 15 bushels. Potatoes are grown for home use, and yields of from 100 to 150 bushels per acre are secured.

The rotation most commonly followed consists of corn, peas, or potatoes for one year, followed by oats and barley one year each, the last crop being seeded down to clover and timothy. Hay is cut for one or two years, and the field may be pastured for one year before being plowed again for a cultivated crop. Manure is usually applied to the sod in the fall or to the plowed field during the winter. The type is easier to cultivate than Superior loam, rolling phase, and while the bowlders and gravel sometimes interfere to some extent with cultivation, a good seed bed can be secured with comparatively little difficulty. On the slopes and hilltops, where the surface has been eroded, the soil is heavier and more difficult to handle than elsewhere. Where the gravel is near the surface, the type is somewhat droughty, though such areas are comparatively small. Where the subsoil is heaviest and the surface undulating, crops of peas sometimes suffer from an excess of moisture during seasons of heavy rainfall.*

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Miami loam:

Mechanical analyses of Miami loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Soil	2.9	6.1	8.4	19.9	11.6	43.4	7.7
Subsoil	1.5	2.9	4.1	9.8	19.5	51.4	10.7

*For methods of improvement for Miami loam see page 32.

FOX SILT LOAM.

Description.—The surface soil of Fox silt loam consists of a medium brown loam, having an average depth of 10 inches and containing some fine sand and a large amount of silt. The soil is fairly loose in structure, but is usually deficient in organic matter. The subsoil consists of a yellowish-brown or sometimes reddish-brown clay loam, which is usually quite gritty. At a depth of from 16 to 24 inches gravel, showing stratification, is usually found. This gravel is mixed with some finely ground rock and consists chiefly of limestone material, though such rocks as granite, quartz, etc., are also represented. In places gravel is scattered over the surface of this type, and the gravel beds sometimes come within a few inches of the surface. Stones and bowlders do not occur upon the surface.

Extent and distribution.—The type is found chiefly in Franklin, the western parts of Carlton and West Kewaunee Townships, and in the eastern part of Montpelier Township, where it is associated with the Kettle Moraine. It covers a total area of nearly 10 square miles.

Topography and drainage.—The surface of the soil is level to gently undulating, and on account of the loose, open character of the subsoil and the gravel beds which occur beneath the whole type, the natural drainage is very good and in places excessive. During late summer or at times of insufficient rainfall the soil is droughty.

Origin.—Fox silt loam consists of glacial and morainic material which has been reworked to a greater or less extent by streams from beneath the ice sheet and deposited in the form of overwash plains. The surface material is sometimes slightly acid, although the subsoil contains a large amount of limestone debris.

Native vegetation.—The original timber growth consisted chiefly of maple and beech, with a scattering of pine, hemlock, and cedar. Practically all of the timber has been removed.

Present agricultural development.—Nearly all of the type is under cultivation and devoted to general farming and dairying. It is a fair soil, though it suffers from drought more than the

Miami loam. The usual crops grown and average yields are as follows: Oats from 30 to 40 bushels, barley from 25 to 35 bushels, rye from 15 to 25 bushels, and clover and timothy about 1½ tons per acre. A little wheat is still grown, yielding from 10 to 15 bushels per acre. Some corn is produced, but mostly for fodder or for the silo. A little alfalfa is also grown with fair success. Of the special crops, peas yield from 15 to 18 bushels, but this crop is quite uncertain, and potatoes from 125 to 150 bushels per acre. The rotation most often followed consists of corn or peas, oats followed by barley, and rye or wheat, with which the land is seeded to clover and timothy. Hay is usually cut for two years and the land may be pastured for a year before again being plowed for corn or peas. Manure is usually applied to the sod. The soil is comparatively easy to cultivate and a good, mellow seed bed can be readily obtained. It can be worked under quite a wide range of moisture conditions. Crops can usually be put out earlier in the spring than on the heavy Superior soils.

The following table shows the results of mechanical analyses of samples of the soil and subsoil of the Fox silt loam:

Mechanical analyses of Fox silt loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Soil	0.9	4.2	5.5	10.3	19.7	53.1	5.8
Subsoil	10.1	14.9	16.1	26.2	11.1	13.3	7.8

CHEMICAL COMPOSITION AND IMPROVEMENT* OF THE HFAVY, UPLAND SOILS OF KEWAUNEE COUNTY

In chemical composition the five soils in this group are quite similar. They all contain approximately 1200 pounds of phosphorus in the surface 8 inches per acre. The relatively large amounts of iron in the Superior soils is liable to render the phos-

* See Bulletin 202, Wisconsin Experiment Station on "How to Improve Our Heavy Clay Soils."

phorus somewhat less available than in the other types containing less iron, and attention should be given each case of low yields to determine by direct experiment whether an addition of this element in fertilizers would increase the yield.

The total amount of potassium present in all of these types is large and varies from about 40,000 pounds in the Miami loam and Fox silt loam to approximately 55,000 pounds in the Superior types. The problem of the potassium supply for crops on these soils is chiefly that of having sufficient organic matter to produce the necessary chemical changes in the inert potassium compounds of the soil to render them available to plants. The total amount of nitrogen in these soils averages from 2,000 to 3,000 pounds to the surface 8 inches per acre. This amount is relatively small and should be increased by the growth of legumes in all rotations.

The amount of lime or lime carbonate contained in these soils is extremely variable. As a rule fields which have been cropped for a number of years, have lost nearly or quite all the lime originally contained in the surface soil, and have in many cases become slightly acid. The subsoil, however, often still contains very large amounts of this material, sometimes running as high as 20 per cent, but for the insurance of good growths of plants requiring lime, especially alfalfa, this will have to be supplied in all cases where the surface shows a distinct acid reaction either by the use of the litmus paper test or the Truog test for soil acidity.†

† As a number of the soils in this area are in an acid condition and would be greatly benefited by the application of lime, every farmer should know how to test his soil for acidity. A very simple and reliable method to detect soil acidity is by the use of blue litmus paper, which can be secured of any good druggist. Take a handful of moist soil and form it into a ball. Break the ball into halves and place a piece of blue litmus paper in the center on one of the halves, and cover over with the other half. After 5 minutes break the ball, and if the paper is pink in spots or over the whole end, the soil is acid." "Soil acidity is also usually indicated by the growth of certain weeds, such as sheep sorrel, horse-tail rush, corn spurry and wood horse-tail." For more information on this subject see Bulletin 230 of the Wisconsin Agricultural Experiment Station.

The Truog test for soil acidity is a new method recently perfected, which enables a more accurate determination to be made in the field, than is possible with the litmus paper test. For information concerning this test write the Soils Dept., U. of W., Madison, Wisconsin.

The most important factors to be considered in the improving of this group of soils are means of increasing and maintaining the supply of humus forming material and phosphorus. Humus forming material can best be supplied by the growth of legumes in rotation with other crops. A very efficient means of increasing the organic matter and nitrogen supply is by plowing under a second crop of clover. The same results might be accomplished if the crop of clover is not turned under, simply by the decay of roots and stubble, but this would require a much longer time. Plowing under a crop of clover not only increases the humus forming material, but it greatly improves the structure of heavy soils.

A 4 to 5 year rotation seems to be best adapted to heavy soils such as are included in this group. The first crop may be small grain, such as oats, barley or wheat, seeded down to clover, with a little timothy mixed in it. The second year clover will be grown, the first cutting for hay and the second left for seed. The third year, crops of mixed clover and timothy will be harvested. Manure should be placed on the sod either before plowing in the fall or on the plowed land in winter. The fourth year the land should be put in cultivated crops consisting of corn, potatoes or roots. In this scheme of crop rotation, one fourth of the land is in grain, one-fourth in clover, one-fourth in mixed clover and timothy, and one-fourth in cultivated crops. Alfalfa can be successfully grown on all soils in this group and the acreage devoted to this crop should be increased, especially where dairying is the chief type of farming followed. It may be grown permanently on the same field, or it may, in part, take the place of clover in a rotation, thus lengthening the rotation by several years.

The phosphorus content of these soils can best be maintained by applying ground rock phosphate. This may be applied at the same time as the stable manure at the rate of about 600 pounds per acre. Subsequent applications of 300 to 500 pounds per acre once during each rotation will doubtless be sufficient to keep up the supply of available phosphorus. If grain farming is followed more phosphorus will be removed from the soil than if dairying is the chief branch of farming. The amount which

should be applied, therefore, will vary somewhat with the type of farming.

All working of the soils in this group, and especially the Superior soils, should be done only when dry enough not to puddle. Plowing when too wet will have a bad effect for 3 or 4 years. To a somewhat less extent the same is true of harrowing and cultivating. The depth of plowing is also a matter needing study. While it is desirable to have the furrow deep, ultimately 7 or 8 inches, it should be deepened only gradually.

The question of thorough drainage* is one of great importance, especially on the Superior soils. Where the surface is flat, as is the case on the Superior clay loam, the land should be plowed in narrow strips leaving dead furrows from 2 to 4 rods apart. These furrows should be kept cleaned out so the water will flow from them into a ditch along the side of the field. By this means very little surface water will stand on the fields even after heavy rains. This system of surface drains should be used to supplement tile drains, and should not be expected in itself to improve the under drainage. The natural drainage of all types in this group could be improved in many cases by tile drains, even where the surface has a gentle slope. At present there is a large amount of land in Kewaunee County which is not producing profitable crops because of deficient drainage. The question of tiling should therefore be given very careful consideration wherever this condition prevails.

The soils of this group are all well adapted to general farming and dairying. While dairying is now an important branch of farming it could well be developed to still greater proportions. More silos should be constructed, and alfalfa should be grown on every dairy farm. The range of crops grown on most farms could doubtless be broadened somewhat with profit. Sugar beets, peas, and some other crops could be grown to a greater extent in many cases. The fruit industry, especially the growing of apples and cherries could be profitably extended on the rolling phase of Superior loam, and the rolling phase of Superior clay loam. Good orchard sites are also found on Miami loam.

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* For more information on drainage consult Bulletin 229, Wisconsin Experiment Station.

CHAPTER III.

GROUP OF LEVEL SANDY SOILS.

PLAINFIELD GRAVELLY SANDY LOAM.

Description.—The surface soil of Plainfield gravelly sandy loam to an average depth of 8 inches consists of a light-brown gravelly sandy loam which is made up largely of medium and coarse sand, fine gravel, and cobblestones, with just enough clay to impart a loamy character and to make the type clod slightly in places when plowed. The structure of the material is loose and open. Its organic matter content is low. Many cobblestones have been removed from the surface. The subsoil consists of a mass of sand, gravel, and cobblestones, loose and open in structure and having a low water-holding capacity. A high percentage of the gravel and stones is limestone material, although rock fragments foreign to the region are also present. The subsoil is stratified.

Extent and distribution.—The type occupies about 5 square miles and is confined chiefly to the western part of Casco and the eastern part of Luxemburg Townships. A few small patches occur farther south in the county in the Kettle Moraine, but all of these are of minor importance.

Topography and drainage.—In general the surface of the type is flat to slightly bumpy. Northeast of Casco and for a short distance to the south it is more broken. Along the Kewaunee River and the stream which flows through Casco Township well-defined terraces have been formed, the lowest of which is considerably above the stream level. While the slopes to the streams are frequently quite steep, the land above has the appearance of an overwash plain. On account of the surface features and the gravelly nature of the material, the natural drainage is excessive

and the type is droughty, though not as much so as might be expected.

Origin.—The material composing Plainfield gravelly sandy loam consists of glacial debris which has been reworked by streams issuing from beneath the ice sheet and again deposited in the form of terraces and overwash plains. While the gravelly material making up much of the type is largely limestone, the surface soil is slightly acid. Because of the loose open structure and droughty condition, the limestone appears to have but little effect upon this type, and it has therefore been classed as Plainfield rather than Fox gravelly sandy loam.

Native vegetation.—The original timber growth consisted chiefly of maple and beech, with some basswood, ironwood, birch, and a scattering of pine and hemlock. In a few localities the pine was quite plentiful. A second growth of poplar is frequently found where the gravel extends to the surface and the type is not cultivated.

Present agricultural development.—The greater part of the type is under cultivation and most of the crops common to the region are grown. The yields, however, do not average as high as on the heavier soils. Oats yield from 20 to 30 bushels per acre; rye, of which considerable is grown, from 15 to 25 bushels; hay, from 1 ton to 1¼ tons per acre. Some wheat and barley are also grown, but the acreage is small and yields are low. Corn does not do well on account of the droughty condition of the soil, except during wet years, when fair yields of fodder are secured. Considerable difficulty is experienced in securing a stand of clover, and as a result timothy is the principal hay crop. Some peas and potatoes are grown as special crops, but the yields are low. The most common rotation followed consists of corn or peas, oats, rye, and hay. The sod is usually manured before being plowed again. No commercial fertilizers are used. The gravel and cobblestones interfere somewhat with cultivation, but fair tilth can be obtained with but little difficulty.

Chemical composition and improvement.—In chemical composition the surface soil of this type to a depth of 8 inches contains approximately 1000 pounds of phosphorus per acre. The amount of potassium is about 25,000 pounds per acre, and nitro-

gen about 2400 pounds per acre. While these are fair amounts of the various elements, they are all considerably lower than in the heavy soils of the area. Because of the loose, open structure of this soil type the water holding capacity is the determining factor in crop production, and in the improvement of this class of land an effort should be made to increase the organic matter content. This will add to the supply of nitrogen, increase the water holding capacity, and the decay of the vegetable matter will assist in making the mineral plant foods available. The growing of green manuring crops to supplement the supply of stable manure, is the most practicable way of increasing the organic matter content of this soil. Legumes are better for this purpose than other classes of crops. While the surface is sometimes slightly acid in places, the subsoil is not acid. In case difficulty is experienced in securing a good stand of clover small applications of ground limestone should be used.

PLAINFIELD SAND.

Description.—The surface soil of Plainfield sand consists of a light-brown medium sand, loose and open in structure, and extending to an average depth of 6 inches. It contains only a small amount of organic matter, except in the valley of the Kewaunee River, where the water table is near the surface and the soil is springy and darker in color than in other places. The subsoil is an orange or reddish-brown, loose, incoherent medium sand, which extends to a depth of about 12 feet, where red clay is usually encountered. A sprinkling of gravel is common on the surface, and gravel beds may be encountered at 3 feet. The subsoil shows stratification in places.

Extent and distribution.—Plainfield sand is of limited extent, occupying an area of about 3 square miles. Its largest development is in southwestern Casco and southeastern Luxemburg Townships. A few small areas occur in West Kewaunee and Carlton Townships.

Topography and drainage.—The surface of the type is flat to gently undulating. South of the railroad in sections 30 and 31, Casco Township, there is a pronounced terrace from 50 to 60 feet high running parallel with the river. The type is more un-

dulating in the valley than on the higher land. The natural drainage is excessive, except in the valley of the Kewaunee River, where a few small tracts are springy.

Origin.—This type consists of glacial material which has been reworked by glacial streams and deposited as overwash plains or as terraces. The surface of the material is in an acid condition.

Native vegetation.—The original timber growth consisted chiefly of white pine, and it is reported that the type supported the best growth of pine to be found in the county.

*Present agricultural development.**—All of the type is cleared except a strip along the Kewaunee River. Rye and oats are the leading crops, but yields are small. From 5 to 15 bushels of rye and 15 to 20 bushels of oats are produced per acre. Timothy seldom yields over 1 ton per acre, and it is very difficult to get a stand of clover. Peas are also grown, but the yields are not such as to make the crop profitable. The system of cropping followed usually consists of corn or peas, oats, rye, and hay. Pasturage on this soil is poor because of insufficient moisture, except in the early spring and summer. Corn is grown principally for fodder and the yield is low.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Plainfield sand:

Mechanical analyses of Plainfield sand.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Soil	2.0	13.5	22.2	40.3	8.2	9.2	4.6
Subsoil	.9	9.3	18.2	55.8	5.0	5.7	5.2

DUNKIRK SAND.

Description.—The surface soil of Dunkirk sand consists of a light to dark-brown sand or loamy sand of medium texture, extending to an average depth of 6 inches. The upper subsoil fre-

*For chemical composition and improvement of this soil see page 41.

quently has a rusty appearance, and at about 2 feet this grades into a yellowish medium sand. The amount of organic matter in the soil is somewhat variable, being low over most of the type, but increasing considerably close to the foot of the bluffs on the lower bench and giving the soil a dark color. Red clay is encountered at 6 to 10 feet below the surface.

Extent and distribution.—Dunkirk sand is limited in extent, comprising less than 2 square miles, It is confined to a narrow strip bordering Lake Michigan and extending from the northeast corner of the county to several miles below Algoma. It is not continuous, however, for the entire distance.

Topography and drainage.—The type occurs as two distinct benches or terraces along the Lake. The surface of these terraces is level to undulating. The natural drainage is good, except at the foot of the bluffs, especially in the lower bench, where the seepage from the higher land keeps the soil wet and springy.

Origin.—The terraces were formed when Lake Michigan was at higher levels than at present, and the sand probably represents beach formations. The lower bench is from 4 to 6 feet and the higher nearly 40 feet above the level of the Lake. The red clay which occurs beneath the deposits of sand is of lacustrine origin.

Native vegetation.—The original timber growth included scrubby oak, with some other hardwoods and a mixture of pine, hemlock, and cedar.

Present agricultural development.—The lower bench is much more limited in extent than the upper, is rather poorly drained in places, and is devoted chiefly to pasture. The upper bench is largely cultivated, and most of the crops common to the region are grown. Oats, rye, and timothy are the chief general farm crops, and of the special crops peas, beans, and potatoes are most extensively grown. The average yields are lower than on the heavier soils, but compare favorably with the returns received from the other sand types of the county.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of Dunkirk sand:

Fig. 1. VIEW SHOWING TYPICAL ROUGH, BROKEN TOPOGRAPHY AS FOUND IN THE MORAINIC REGION.

This topography is characteristic of soils of the Rodman series, especially Rodman gravel. These soils are droughty, and most of the types have a rather low agricultural value.

Fig. 2. VIEW SHOWING LEVEL SURFACE FEATURES WHICH ARE CHARACTERISTIC OF SOILS BELONGING TO THE FOX AND THE PLAINFIELD SERIES.

The Fox soils are seldom acid, are heavier in texture, and have a higher agricultural value than the Plainfield soils.

Mechanical analyses of Dunkirk sand.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Soil	2.9	9.0	24.1	49.7	1.9	6.9	5.7
Subsoil	.6	4.7	23.1	65.6	1.6	1.6	2.7

CHEMICAL COMPOSITION AND IMPROVEMENT OF PLAINFIELD SAND AND DUNKIRK SAND.

Chemical analyses of these two types indicate that they are deficient in practically all of the essential plant food elements. The total amount of phosphorus in the surface 8 inches averages from 500 to 800 pounds per acre, the potassium is about 18,000 pounds per acre, and the nitrogen from 1000 to 1200 pounds per acre. In addition to the deficiency in plant food, these soils are also acid, and before such crops as clover and alfalfa can be grown successfully it will be necessary to correct this condition by the use of ground limestone, or some other form of lime.

In improving soil of this character an attempt should first be made to secure a good stand of clover. About one ton of ground limestone should be applied per acre, and in addition to this 600 to 1000 pounds of rock phosphate and 150 pounds of the muriate or sulphate of potash should be applied per acre. By the use of this combination of fertilizers and a three year rotation consisting of small grain, clover, and potatoes or some other cultivated crop the fertility of these soils should be materially increased, and profitable yields secured. Until the fertility is well established the second crop of clover should be plowed under and whatever manure is available should also be applied to the land either at this time or as a top dressing after the field is plowed.

Where located close to shipping points the trucking industry might be profitably developed on these soils. They warm up early in the spring, and respond quickly to the use of commercial fertilizers.

CHAPTER IV.

GROUP OF DROUGHTY SOILS.

RODMAN GRAVELLY LOAM.

Description.—The surface soil of Rodman gravelly loam consists of a brownish-gray sandy loam of medium texture, extending to an average depth of 8 inches, and containing considerable gravel. Gravel and bowlders are commonly found upon the surface, frequently in sufficient quantities to interfere with cultivation. The subsoil consists of a reddish-brown gravelly clay loam to a depth of 12 to 14 inches, where it grades into a mass of sand and gravel. Bowlders are also found mixed with the soil and subsoil and it is frequently impossible to bore to a greater depth than 18 inches. The gravel and stones consist largely of limestone, though other rocks foreign to this region, such as granite and quartz are also found.

Extent and distribution.—Rodman gravelly loam is of small extent and occurs in small and widely scattered areas. A narrow tract about 3 miles long is found in the western part of West Kewaunee Township, a smaller area lies due south from Pilsen, in Montpelier Township, a few patches occur in the northwestern part of Franklin and the southwestern part of Carlton Townships, and several areas are scattered along the Kewaunee River northwest of Casco Junction.

Topography and drainage.—The surface of the type varies from gently rolling to rolling and bumpy. In the Montpelier area some of the hills rise about 100 feet above the level of surrounding soils. On account of the uneven surface features and the loose, open nature of the subsoil the natural drainage is good, often excessive, and the soil is droughty, except during seasons of abundant rainfall or when the rainfall is well distributed.

Origin—Rodman gravelly loam is of glacial origin and forms a part of the Kettle Moraine. Much of the material consists of ground-up limestone from the underlying bedrock. In some places the gravel shows stratification, indicating that some of the material at least has been influenced by the action of water. Because of the high content of limestone material the soil is not in an acid condition.

Native vegetation.—The original timber growth consisted chiefly of maple, oak, beech, and hickory, with now and then some pine and hemlock. Quite a large part of the type is still in timber.

Present agricultural development.—Rodman gravelly loam is but little utilized for cultivated crops, since it is droughty and quite rough. In the areas of good land between the gravelly hills good crops could be produced, but such tracts are irregular and often inconveniently located. Where the type is cultivated the yields are low, except in a few places where the surface soil is deeper than usual. Good grazing is furnished during the spring and early summer, but during the dry part of the summer the grass often dies down.*

RODMAN GRAVELLY SANDY LOAM.

Description.—The surface soil of Rodman gravelly sandy loam consists of a yellowish or grayish brown sandy loam, with an average depth of 8 inches. It contains a large quantity of gravel, and in places bowlders occur upon the surface. The structure of the material is loose and open and the amount of organic matter present is small. The knolls are very gravelly, while in the depressions the soil is quite deep and rich. The subsoil consists of a brownish, sandy gravelly loam, which grades into yellow sandy material and gravel at about 18 inches. A gravel bed occurs under most of the type below 2 or 3 feet. In a few instances traces of red clay were found in the gravel beneath this type.

Extent and distribution.—Rodman gravelly sandy loam is of very small extent and of little importance. It is found in West

*For methods of improvement of this type see page 48.

Kewaunee, Luxemburg, Lincoln, and Red River Townships, but the areas are small and scattered.

Topography and drainage.—For the most part the surface is bumpy or gently rolling or rolling. In sections 10 and 11 Luxemburg Township, the type occurs as a ridge and is rather hilly. On account of the surface features and the gravelly nature of the soil, the natural drainage is somewhat excessive and the type is droughty.

Origin.—Rodman gravelly sandy loam is derived from the glacial material which occurs here as a part of the Kettle Moraine. The greater part of the gravel and stones in the type are of limestone material, though some granite, quartz, and other rocks foreign to the region are also present. The gravel in the subsoil shows stratification in places, and doubtless most of the material was influenced to a greater or less extent by the movement of water beneath the ice sheet and along the glacial front.

Native vegetation.—The original timber growth consisted of beech and maple, with some white pine and hemlock. All of the good timber has been removed.

Present agricultural development.—Much of the type has never been put under cultivation, but where tilled the crops common to the region are grown. The yields, however, are low. The methods of cultivation and the rotations followed are similar to those on the other sandy soils of the area. The presence of the gravel and bowlders somewhat interferes with tillage, and the steep slopes also sometimes prohibit cultivation. Where not plowed the type is used for grazing and furnishes fair pasture during the spring and early summer.*

RODMAN SANDY LOAM.

Description.—The surface soil of Rodman sandy loam consists of a yellowish-brown medium sand, with an average depth of 8 inches, and containing an appreciable amount of fine sand but only a comparatively small quantity of organic matter. In structure the material is rather loose and the amount of clay present is not large. The subsoil consists of a fine to medium

*For methods of improvement for this type see page 48.

sand of a yellowish color, which usually grades into a sticky sandy loam at from 30 to 36 inches. A small quantity of gravel is mixed with the surface soil, while gravelly material and occasionally a gravel bed is encountered at a depth of about 3 feet. Bowlders are sometimes present on the surface. As a whole this soil is somewhat lighter in texture than the typical Rodman sandy loam as mapped in other areas.

Extent and distribution.—The type is not extensive. It is found in the morainic portion of the county and is confined chiefly to Carlton, Franklin, Montpelier, West Kewaunee, and Casco Townships. The areas range in size from a few acres to about 1 square mile.

Topography and drainage.—The surface varies from gently rolling to rolling, with a few small undulating areas. On account of the surface features and the loose, open character of the material, the natural drainage is excessive and the soil is droughty, although the sticky sandy loam retains moisture fairly well. Erosion is not a problem to be considered on this soil.

Origin.—Rodman sandy loam is of glacial morainic origin and some of the material at least is stratified. A large amount of the gravel and stones are of limestone, having been ground from the underlying rock by the ice sheet. Other rocks foreign to the region are also present, but in smaller quantities. The surface soil frequently shows some acidity.

Native vegetation.—The original timber growth consisted chiefly of maple and beech, with some white pine and hemlock. The type has been cleared of the virgin forests.

Present agricultural development.—Most of Rodman sandy loam is under cultivation and during normal seasons fair crops are secured. The usual crops grown and the yields secured are as follows: Oats, 20 to 30 bushels; rye, 15 to 20 bushels; wheat, grown but little, 5 to 15 bushels; peas, from 8 to 12 bushels; and hay, three-fourths of a ton to 1½ tons per acre. But little corn is grown to maturity, though some is produced for fodder. The rotation most commonly followed consists of corn or peas one year, oats one year, rye one year, or oats seeded to clover and timothy. After hay is cut for one or two years the field may be pastured, if there is no low, wet pasture land on the farm. When

other pasture is afforded this soil is not grazed at all. Stable manure is the only fertilizer applied to the type and the methods of cultivation could be improved upon. No difficulty is experienced in securing a good seed bed, and only light tools are required for handling the soil.*

The following table shows the results of mechanical anaylses of samples of the soil and subsoil of Rodman sandy loam:

Mechanical analyses of Rodman sandy loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Soil	1.2	5.7	10.5	41.3	20.7	16.6	4.1
Subsoil	.2	1.5	9.3	56.6	24.3	4.8	3.2

RODMAN FINE SAND.

Description.—The surface soil of Rodman fine sand consists of a grayish-yellow, loose, incoherent medium sand, to an average depth of 6 inches and containing only a very small amount of organic matter. Where not protected by a growing crop the material sometimes drifts. In the low areas the soil is darker in color than in other places. The subsoil consists of a loose, incoherent yellow sand, usually somewhat finer in texture than the surface material. At from 5 to 10 feet gravelly clay is encountered and this usually grades into very gravelly and stony material. Small amounts of gravel are scattered through the surface soil and the subsoil in places.

Extent and distribution.—The type is of very small extent, occupying only a few square miles. It is confined to the morainic section and small areas occur in western Carlton, West Kewaunee, and to a smaller extent in Montpelier and Casco Townships.

Topography and drainage.—The surface of the type is gently rolling in topography. On account of the very sandy nature of

*For methods of improvement of this type see page 48.

the material, the natural drainage is excessive, and the type is droughty.

Origin.—The material forming this soil consists of glacial debris which was influenced to a considerable extent by the action of water, and in part deposited as kames and eskers. Cuts show the material to be stratified.

Native vegetation.—The original timber growth consisted chiefly of white pine, with some hemlock and a few hardwood varieties. All of the timber has been removed.

Present agricultural development.—The crops common to the region are grown upon this type, but the yields are low and the dry weather frequently causes crop failures. Crop rotations have not been definitely established and the methods of cultivation followed are not especially adapted to this type of soil.*

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Rodman fine sand.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	Per cent.	Per cent	Per cent.	Per cent.	Per cent.	Per cent.
Soil	0.1	2.9	15.0	64.3	8.3	5.2	3.9
Subsoil	0	1.7	16.7	67.0	9.7	1.9	2.9

RODMAN GRAVEL.

Description.—The surface soil of Rodman gravel consists of a light-brown gravelly loam, about 4 inches deep, and is underlain by beds of gravel and gravelly sand. Gravel and bowlders are present on the surface and are mixed with both soil and subsoil.

Extent and distribution.—The type is of very small extent and of little importance. Small areas are found in Red River, Luxemburg, and Montpelier, Townships and in a number of other sections of the county, but always in small patches.

*For methods for the improvement of Rodman fine sand see page 48.

Topography and drainage.—The type is characterized by a bumpy topography, with numerous kettle holes and a number of long, narrow ridges. Some areas consisting of single hills of gravel are encountered. Some of the areas are gently rolling. The differences in elevation range from 10 to 50 feet or more from the depressions to the crests of the ridges and hills. The natural drainage is excessive and the type is very droughty.

Origin.—Rodman gravel is of glacial origin and represents stratified morainic material in the form of kames and eskers. A very large percentage of the gravel, cobblestones, and bowlders consists of limestone, though some stones foreign to the region are also found. On account of the high content of limestone material the type is not acid.

Native vegetation.—The original timber growth consisted chiefly of maple and beech, with a scattering of pine and hemlock. A portion of the type is still in timber, but the best timber has been removed.

Present agricultural development.—A few fields have been cultivated, but not with success. The soil furnishes pasture for the spring and early summer. It must be considered a non-agricultural soil.

CHEMICAL COMPOSITION AND IMPROVEMENT OF RODMAN GRAVELLY LOAM, GRAVELLY SANDY LOAM, SANDY LOAM AND FINE SAND.

The differences between gravelly soils and those relatively free from stony matter in this section are chiefly due to the fact that most of the gravel is limestone. While the phosphorus content may frequently be fairly high a considerable portion is probably contained in the coarser grains of the soil and so is not as readily available as that in soils of finer texture. The actual amount of phosphorus in this group of soils as indicated by analyses made, averages from 800 to 1000 pounds per acre 8 inches. The sandy types contain a smaller amount than the gravelly soils of the group. The amount of potassium is variable but is sometimes as high as in the heavy, light colored types of the county. Its availability depends largely upon the actively decomposing organic matter in the soil, and as the supply of or-

ganic matter and nitrogen is limited, the soils are deficient in available potassium.

Because of their uneven topography, and their loose, open structure the water holding capacity of all of these types is small and their agricultural value is low. The steepest portions of these soils should be kept in pasture as much of the time as possible, as there is some danger from erosion, especially on the gravelly loam, and gravelly sandy loam types. Where the soils are cultivated an effort should be made to increase the organic matter content. Where an acid condition exists this may be corrected by the use of some form of lime. Clover should be started, and alfalfa may also be grown successfully especially on the gravelly loam type. Green manuring should be practiced and the organic matter content and the water holding capacity thus increased. It will probably be unnecessary to use commercial fertilizers except where difficulty is experienced in getting clover or alfalfa started, in which case about 600 pounds of rock phosphate, and 150 pounds of the sulphate or muriate of potash should be applied per acre. Small grain, clover, and potatoes or corn is a good rotation to follow on these soils, especially the more sandy types. Trucking crops could also be grown to advantage, where shipping facilities are adequate.

CHAPTER V.

GROUP OF LOW POORLY DRAINED SOILS.

POYGAN SILT LOAM

Description.—The surface soil of Poygan silt loam to an average depth of 10 inches consists of a black silt loam to silty clay loam, and contains a large amount of organic matter. The subsoil is a red, heavy silty clay, identical with the subsoil of the Kewaunee clay loam. The material is stiff and tenacious, but contains considerable finely ground limestone and is quite calcareous. In the areas back from the shore of Green Bay the upper subsoil consists of a yellowish-brown clay loam and the red clay loam is not encountered until a depth of from 16 to 18 inches is reached.

Extent and distribution.—This type is very limited in extent and of comparatively little importance, yet it constitutes a distinct type. It is found as a narrow strip bordering the shore of Green Bay and in a few small areas in Red River Township.

Topography and drainage.—The surface of the type is level, and on account of the heavy nature of the soil and subsoil, the natural drainage is poor. Practically all of the type should be tile drained.

Origin.—The material composing the soil is largely of lacustrine origin, probably influenced somewhat by glacial action since the first deposition. On account of its low position and poor drainage, there has been a growth and decay of vegetation in the presence of moisture, which accounts for its high organic matter content and dark color. The surface soil frequently shows slight acidity, but the subsoil is calcareous.

Native vegetation.—The original timber growth consisted chiefly of elm, ash, cedar, and hemlock, with a few other varieties. The timber has all been removed.

*Present agricultural development.**—The soil is naturally strong and productive, and practically all of it has been cleared and cultivated. The lack of drainage, however, is the limiting factor, and in wet seasons crops are frequently lost entirely. Oats yield 30 to 35 bushels, wheat 12 to 15 bushels, and hay, consisting chiefly of timothy, about 2 tons per acre. Corn does fairly well and gives good yields of fodder. On drying, the soil cracks and cultivation must be confined to a rather narrow range of moisture conditions or difficulty will be experienced in securing good tilth. If worked when moisture conditions are most favorable, a good seed bed can be obtained.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Poygan silt loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Soil	0.3	1.7	3.8	11.4	11.8	53.6	17.3
Subsoil	.6	2.5	4.2	12.7	9.5	38.7	31.5

CLYDE SILT LOAM.

Description.—The surface soil of Clyde silt loam consists of a dark-gray to black silt loam, extending to an average depth of 12 inches and containing a very large amount of organic matter. The subsoil consists of a drab or bluish silty clay or clay loam, which contains considerable limestone material in the form of grit and gravel. Iron concretions are also present in places. The type as found in different parts of the county shows considerable variation. In the marsh areas in the southeastern part of Lincoln Township the surface consists of about 4 to 8 inches of well-decomposed peat, underlain by a black silt loam to 12 inches, where a drab-colored clay is encountered. This clay has a pinkish tinge at 2 to 3 feet. Clay resembling that of the Kewaunee clay loam is frequently found in the deep

*For chemical composition and improvement of this soil see page 53.

subsoil. In section 33, Montpelier Township, the soil is very heavy and somewhat similar to Clyde clay loam. In some places the type is underlain by white sand, but the variations are not of sufficient extent or importance to be separated on the soil map.

Extent and distribution.—Clyde silt loam occupies low, swampy depressions varying in size from a few acres to over a square mile in extent. The areas are found in all parts of the county.

Topography and drainage.—The surface of the type is level, and owing to its low position and heavy subsoil is very poorly drained. Tile drains or open ditches will be necessary before cultivated crops can be grown successfully.

Origin.—The type occupies marshy depressions, some of which may be old lake beds. The material consists of glacial and lacustrine débris, with which there has accumulated a large amount of vegetable matter in the presence of moisture, resulting in the high organic matter content and the characteristic dark color. While the subsoil is calcareous, the surface may be acid in a few places.

Native vegetation.—The original timber growth was chiefly black ash, elm, and cedar, with a very few maples, willows, etc. Most of the type is still in timber.

Present agricultural development.—Only a small proportion of the type has been cleared, and most of this is used for pasture, as drainage is necessary before other crops can be safely grown.

The following table shows the result of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Clyde silt loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Soil	0.2	9.1	4.4	10.0	5.0	52.4	18.2
Subsoil	.3	1.5	1.7	6.2	6.9	71.0	12.2

CHEMICAL COMPOSITION AND IMPROVEMENT OF POYGAN SILT LOAM AND CLYDE SILT LOAM.

These soils are characterized by having a relatively large amount of organic matter, and as is usually the case accumulations of organic matter increase the total content of phosphorus. This does not necessarily mean, however, that this element is readily available. Its availability will depend largely upon the rate of decomposition of the vegetable matter. The total amount of phosphorus present in the surface 8 inches of these soils is approximately 2,000 pounds per acre. The total amount of potassium in these soils is always sufficient, and frequently very large, but the chief question with this element is concerning conditions affecting its availability. Where the amount of organic matter is largest, and the surface soil deepest, as in poorly drained depressions, it may be found profitable to use potassium fertilizers for a few years after reclaiming this class of land. After the soil has become thoroughly aerated, however, it is thought that the supply of available potassium in this type will be sufficient for all general farm crops. If special crops, such as cabbage, are to be grown it may be found advisable to use small amounts of the muriate of potash. The supply of nitrogen is large and averages over 10,000 pounds per acre to the surface 8 inches.

The first question to be considered in the improving of these types is one of drainage. When thoroughly drained they make good general farming soils, and are adapted to most of the general farming crops grown in the region.

POYGAN SAND.

Description.—The surface soil of Poygan sand consists of 10 inches of dark-brown or black medium sand or light sandy loam. It is rich in organic matter and quite loose and mellow under cultivation. The subsoil is a grayish or yellowish sand, extending to a depth of 2 to 3 feet, where red clay is encountered.

Extent and distribution.—The type is of very limited extent, occupying less than one-fourth square mile, and is confined to a

narrow strip along the shore of Green Bay, in the northwestern corner of the county.

Topography and drainage.—The surface is level to undulating, and on account of its sandy nature the drainage is good. The soil does not suffer materially during dry weather, as the water table is comparatively near the surface and the clay assists in retaining moisture.

Origin.—The red clay underlying the type is of lacustrine origin. The sandy material is largely of glacial origin, but has doubtless been acted upon by the waters of Green Bay when at a higher level than at present, since the type occurs chiefly as a bench along the shore of the bay. The sand may represent in part a beach formation upon which there has been a growth and decay of vegetation in the presence of moisture, giving rise to the organic-matter content and the dark color of the soil. The surface soil is acid, but the red clay subsoil is of a calcareous nature.

Native vegetation.—The original timber consisted chiefly of a little hardwood, including maple and ash, with some hemlock and a few other varieties.

Present agricultural development.—Most of the type is cleared, and part of it is devoted to cultivated crops while the remainder is used chiefly for pasture. The chief crops raised are oats, corn and potatoes. Because of its small extent no chemical analyses were made.

The following table shows the results of mechanical analyses of samples of the soil and subsoil of Poygan sand:

Mechanical analyses of Poygan sand.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Soil	0.5	7.1	45.8	29.6	2.3	10.7	3.4
Subsoil	.7	5.8	35.0	33.2	5.3	10.3	9.8

GENESEE LOAM.

Description.—The surface soil of Genesee loam consists of a brown, heavy loam or light clay loam, extending to a depth of 10 inches. The subsoil is a brown or reddish-brown silty clay loam, somewhat lighter in color than the soil, and quite compact and impervious. In some localities it approaches in character Superior clay loam. In places some gritty material is mixed with the subsoil, and a few stones are occasionally found on the surface. Immediately along the stream the surface is darker than at the foot of the bluffs.

Extent and distribution.—This type is of limited extent and of minor importance. It occurs chiefly in the bottoms along the Kewaunee River and its tributaries and also along some of the smaller streams in the area.

Topography and drainage.—The surface of the type is nearly level, with only a gentle slope from the foot of the bluffs down to the stream. The type occupies the first bottoms and is subject to overflow. On account of its low position and heavy character the natural drainage is poor.

Origin.—The material composing the type is of alluvial origin and derived from the wash from glacial and lacustrine soils of the upland.

Native vegetation.—The original timber growth consisted chiefly of elm, ash, cedar, a few pines, and hemlock. A portion of the type is still in timber.

*Present agricultural development.**—Only the better drained areas bordering the upland are under cultivation. The remainder is in pasture and good grazing is furnished throughout the entire season. Where farmed, oats, barley, rye, corn, and hay are grown with success, although over all of the bottoms there is danger of overflow and damage to the crops during seasons of the heaviest rains.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of Genesee loam:

*For chemical composition of this soil see page 57.

Mechanical analyses of Genesee loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Soil	0.7	4.6	7.7	21.3	13.3	35 4	16.7
Subsoil	.2	1.8	3.7	11.9	10.9	43.8	26.8

GENESEE FINE SANDY LOAM.

Description.—The surface soil of Genesee fine sandy loam consists of a brown or dark-brown loam, extending to an average depth of 10 inches. The type as a whole contains considerable fine sand, and spots of sand too small to map are frequently found. A scattering of gravel may occur upon the surface and bowlders are plentiful over limited areas. The subsoil consists of a loam or clay loam, lighter in color than the soil and extending to a depth of from 12 to 21 inches, where gravel and sand are usually encountered. The underlying limestone is frequently within reach of the auger and outcrops are quite numerous. In section 14, West Kewaunee Township, on the north side of the river, there are only a few inches of soil over the rock in places, and over several areas the limestone is entirely bare. On the south side of the river the soil is from 2 to 3 feet deep over the rock. Over small areas the surface is strewn with bowlders to such an extent as to interfere with cultivation.

Extent and distribution.—The type is inextensive and of little importance. It is confined to the bottom lands along the valley of the Kewaunee River and its tributaries.

Topography and drainage.—The surface is nearly level, with usually a gentle slope from the foot of the higher land down to the stream banks. Owing to the medium and coarse material in the subsoil and the loamy nature of the surface, the natural drainage of the type is fairly good. Where the gravel lies near the surface the type suffers somewhat from drought during late summer. A great part of the type is subject to overflow and some damage to crops results from this source. After the water

recedes, however, the land drains quite rapidly. Some of the lowest areas would be benefited by tile drains.

Origin.—Genesee fine sandy loam is of alluvial origin and the material composing the soil has been washed from the glacial and lacustrine deposits of the surrounding upland region. The surface material shows slight acidity.

Native vegetation.—The original timber growth consisted chiefly of elm, ash, hemlock, pine, and cedar. Over areas in which the rock closely approaches the surface and in some other places the timber is still standing.

Present agricultural development.—Excepting the stony and rocky areas, most of the type is cleared and cultivated. All of the crops common to the region are grown and yields are good. Clover does better than on most of the upland types. Potatoes yield from 100 to 125 bushels per acre. The portion of the type not cultivated is pastured.

The following table gives the results of a mechanical analysis of a sample of soil of Genesee fine sandy loam:

Mechanical analysis of Genesee fine sandy loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Soil	4.0	8.4	10.2	19.7	8.0	34.7	14.7

CHEMICAL COMPOSITION AND IMPROVEMENT OF GENESEE LOAM, AND GENESEE FINE SANDY LOAM.

The chemical analyses of these soils indicate that they are well supplied with all of the essential elements of plant food. The total amount of phosphorus in the surface 8 inches will average from 1,500 to 2,000 pounds per acre, the amount of potassium about 35,000 pounds, and the amount of nitrogen about 5,000 pounds per acre. In addition they contain a considerable amount of lime carbonate, and the soil is not acid.

In the improvement of these soils the chief question, especially on the loam type, is one of drainage. The surface is level, and the soils are low lying, so that during spring and early summer there is usually a surplus of moisture, as the types are subject to overflow. Tile drains would greatly assist in carrying off the water quickly and in permitting the soil to warm up more quickly in the spring. These types are adapted to the same crops as the heavy upland soils of the area, and the same rotations may be practiced.

CHAPTER VI.

GROUP OF MISCELLANEOUS SOILS.

FOX SANDY LOAM.

Description.—The surface soil of Fox sandy loam consists of a light-brown or grayish medium sandy loam, having a loose structure, and extending to an average depth of 8 inches. It contains only a small amount of organic matter, except in depressions, where slight accumulations occur. The subsoil consists of a yellowish-brown or reddish-brown medium sand, which becomes somewhat loamy at from 12 to 18 inches. A thin layer of brownish clay loam is sometimes encountered at about 18 inches. Below this depth beds of medium to coarse sand and fine gravel showing stratification in places are found. The gravel and small rock fragments are somewhat angular and show but little indication of water action.

Extent and distribution.—The type is of small extent and occupies a total area of 2,048 acres. Patches are found in Franklin, West Kewaunee, Casco, and Carlton Townships.

Topography and drainage.—The surface of Fox sandy loam is flat to gently undulating, and on account of the underlying beds of sand and gravel and the loose structure of the surface soil the natural drainage is excessive and the soil is droughty.

Origin.—The material composing this type consists of glacial débris which has been reworked by glacial streams issuing from beneath the ice sheet and redeposited in the form of overwash plains. While the subsoil is rich in limestone gravel and ground-up rock, the surface soil shows an acid condition.

Native vegetation.—The original timber growth consisted chiefly of pine and hemlock, with some beech, maple, and a few other hardwoods.

*Present agricultural development.**—The greater part of the type is under cultivation and during normal seasons fair crops are obtained. The type is so inextensive that there are no farms and but few fields situated entirely upon it, and no special system of rotation particularly adapted to it has been worked out. In crop adaptation and size of yields the type is slightly better than the Rodman sandy loam, chiefly because the level and somewhat lower topography enables it to retain more moisture.

SUPERIOR FINE SANDY LOAM, ROLLING PHASE.

Description.—The surface soil of this type consists of a brown fine sandy loam or loamy sand, having an average depth of 8 inches. This is underlain by a yellow or brownish-yellow medium sand, extending to a depth of 2 to 3 feet, where red clay is encountered. In some of the areas gravelly material is found in the subsoil. The depth of the sandy covering over the clay is variable, and may be over 3 feet. In a number of places the clay appears at the surface, but these variations were seldom of sufficient extent to be mapped separately. Where the deep sand was developed widely enough it was classed with the Rodman fine sand, while the clay exposures were mapped as Superior clay loam, rolling phase, when of sufficient extent. The areas northeast of Algoma contain more silt and fine sand than the typical soil.

Extent and distribution.—This type is of very limited extent, covering a total area of only about 3 square miles. The largest area is found about 5 miles northeast of Algoma, along the lake shore. Small patches were mapped along the shore of Green Bay, in the western part of West Kewaunee Township, in the eastern part of Carlton Township along the lake, and in a few other sections, mostly in the northern part of the county.

Topography and drainage.—The topography of the type as a whole is gently rolling to rolling, although over a portion of its extent it is undulating or slightly bumpy. It is sometimes found as very low, narrow ridges only a few feet above the surround-

*For chemical composition and improvement of this type see page 62.

ing soils. The natural drainage of the type is good. It retains moisture well on account of the underlying clay.

Origin.—The heavy clay is of the same origin as the heavy portion of other Superior types. The sandy covering is in part glacial débris dumped by the ice sheet and in part a wind-blown deposit. Some of the ridges have the appearance of eskers, containing considerable gravel, which shows stratification in places. The sandy soil shows acidity in places and a growth of sorrel is frequently seen. The clay subsoil is not acid.

Native vegetation.—The original timber growth consisted chiefly of pine with some hardwoods, hemlock, and cedar. All of the best timber has been cut and the type cleared.

Present agricultural development.—The Superior fine sandy rolling phase, is considered a fairly good general farming soil and nearly all of it is under cultivation. It is easy to cultivate and responds well to fertilization, stable manure being the only fertilizer used to any extent. Average yields of 40 to 65 bushels of corn, 20 to 30 bushels of oats, 20 to 25 bushels of barley, 15 to 25 bushels of rye, and 100 to 125 bushels of potatoes per acre are obtained, these being the usual crops grown. Very little wheat and hay are produced.

The price of land of this type ranges from $40 to $65 an acre.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of Superior fine sandy loam, rolling phase.

Mechanical analyses of Superior fine sandy loam, rolling phase.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Soil	0.4	5.0	17.7	38.4	13.4	14.7	10.2
Subsoil	.0	6.3	23.0	40.0	13.4	10.2	6.6

CHEMICAL ANALYSES AND IMPROVEMENT OF FOX SANDY LOAM, AND SUPERIOR FINE SANDY LOAM, ROLLING PHASE.

These soils are deficient in phosphorus, but contain fair amounts of potassium and nitrogen. The subsoil contains a considerable amount of lime carbonate, but the surface is slightly acid, and before clover or alfalfa will make their best growth some form of lime should be applied. In the improvement of these soils, which are both of very limited extent, the same methods may be followed as were suggested for Plainfield sand on page 41, though these types should respond more quickly to careful management because of the larger amount of fine material which they contain.

PEAT.

The material included in this type consists of vegetable matter in varying stages of decomposition, with which there is sometimes incorporated a small amount of mineral matter. The color is dark brown to black, and the material extends to a depth of from 8 inches to considerably more than 6 feet. Probably the larger part of the Peat is thoroughly decomposed and of a black color, though some of it is still in a fibrous condition. The underlying material consists chiefly of clay, though sand was found under some of the marshes. The beds of sand are not continuous, however, and appear to be of comparatively small extent.

The three largest areas of Peat, occupying about 3 square miles each, are found in the eastern part of Lincoln, the northeastern part of Red River, and the northwestern part of West Kewaunee Townships. Areas of about a square mile each occur at the mouth of the Kewaunee River and in the northwestern part of Franklin Township. Numerous smaller patches are found in all the townships of the county.

The areas of Peat are all level and the drainage is very poor.

The original timber growth on this type consisted of tamarack and black ash, with some elm, cedar, soft maple, and willow. Where the Peat is deepest the tamaracks are the chief growth,

while around the borders of the marshes or where the Peat is shallow black ash is the predominating tree growth. A few of the swamps are timbered chiefly with white cedar. Much of the timber is still standing, though nearly all of the cedar suitable for posts has been cut. On the marsh at Kewaunee the growth consists only of wild grasses.

The areas of Peat in Kewaunee County have not been reclaimed, and it is evident that comparatively little thought has been given to the drainage of the larger marshes.

The first and most important problem in the improvement of the Peat type is the question of drainage. It is thought that practically all of the marshes in the county, except at the mouth of Kewaunee River, could be drained and profitably cultivated. The marsh in West Kewaunee has considerable sand underneath it, and for this reason some portions of it might not be as productive or lasting as the other large marshes where clay is the underlying material. The marsh at Kewaunee is but little above the level of the lake and could not be reclaimed without a very expensive system of diking. It is too soft at present to permit the cutting of the marsh hay. Before drainage projects are undertaken on any of the larger marshes accurate levels should be taken to determine exactly the fall available and the opinion of experts secured as to the best methods to be followed in the laying out and constructing the drains. When reclaimed the Peat will be adapted ot a variety of crops, including most of the general farm crops now grown on the uplands. It is rich in nitrogen, but would doubtless require the application of mineral fertilizers in order to keep up its productivity.

Chemical composition and improvement.—As Peat is made up largely of vegetable matter the amount of the mineral elements is low. The total weight of phosphorus will average approximately 600 pounds per acre to the surface 8 inches, while the potassium supply will average about 700 pounds per acre. It will be seen on comparison of these statements with those made on the composition of the heavy upland soils of this area that the amount of potassium in particular is extremely small. The amount of nitrogen in Peat is large and will run about 15,000 pounds per acre. The Peat marshes in this area are seldom

acid on account of the percolation of lime-containing water from higher lands.

The first step in the improvement of the Peat in this area is a question of drainage. When this has been thoroughly accomplished, and the land put under cultivation it will be necessary to supply mineral plant food in the form of commercial fertilizers. The supply of potash in the Peat may be sufficient for a few crops, but it should not be permitted to be exhausted before more is added. About 150 pounds of the muriate or sulphate of potash per acre will be sufficient for such crops as corn or potatoes. Phosphorus should be supplied by the use of rock phosphate at the rate of 1,000 pounds per acre followed by applications of about half this amount every 3 or 4 years. As Peat is rich in nitrogen fertilizers containing this element need not be applied. When properly handled Peat will produce profitable crops of corn, potatoes, alsike clover, timothy, and a number of other general farm crops, as well as special crops such as celery, onions, etc.

CHAPTER VII.

GENERAL AGRICULTURE OF KEWAUNEE COUNTY.

Settlement was made in Kewaunee County as early as 1837, and at one time in its early history the town of Kewaunee was a rival of Chicago. The actual agricultural development of the region began about 1855–1860. During this period a large number of Bohemians, Belgians, Poles, Germans, and some Americans came into the county and began farming operations. Lumbering was an important industry for a considerable period, but the settler followed the lumberjack quite closely and the time which elapsed between the cutting of the timber and the clearing of the land was not nearly so great as in many other parts of the State.

The early methods of farming were crude. Cultivation was not thorough and the question of crop rotation received but little consideration. The leading type of farming consisted of the production of grain, and wheat was the principal crop until a comparatively recent date. Some oats, barley, and a little corn for fodder were also grown. As has been the experience in other sections of the State, the continued cropping, together with damage from pests and other causes, gradually reduced the yields of and profits from wheat until attention was finally given more largely to other crops.

With the decline in wheat growing a more diversified system of farming was developed, and at present the type of agriculture most largely followed consists of general farming in conjunction with dairying, which industry is gradually increasing in importance. All portions of the region surveyed are well settled, and the farms are comparatively small. The general farm crops grown at the present time in order of the acreage devoted to them consist of hay, oats, barley, rye, wheat, potatoes,

and corn, with a small quantity of flax and buckwheat. The figures given below are taken from the report of the Thirteenth Census and cover the crops for the year 1909. Variations in acreage occur from year to year, owing to various causes, but this data will give a fair idea of the relative importance of the crops grown.

The total area devoted to hay of all kinds was 40,974 acres, from which a yield of 68,153 tons, or an average of about 1.5 tons per acre, was secured. Of this hay a little over half consisted of clover and timothy mixed, about one-fourth was timothy alone, and about one-twentieth clover. Very little alfalfa is grown and only 30 acres were reported, with an average yield of slightly over 2 tons per acre. Marsh hay is cut from a few of the low, wet tracts, but the quantity is not large. Such crops as peas and oats are not utilized to any extent for hay. The greater proportion of the hay is fed to stock on the farms where it is grown, although some farmers make a practice of selling a part of the crop each year.

Oats is the most extensively grown grain crop in Kewaunee County, and the yield in 1909 from 20,142 acres was 613,246 bushels, or about 34 bushels per acre. This crop seems to be fairly well adapted to the soil and climatic conditions, and practically every farmer in the area grows some oats every year. The question of the selection of good seed is receiving more attention than formerly, and as a result the quality and yield may be expected to increase. Most of the crop is fed on the farm, but a number of farmers sell some of the grain each year.

The yield of barley from 10,106 acres was 261,131 bushels, or about 25 bushels per acre. This may be considered as the leading money crop of the county, though a small quantity is fed to stock on some of the farms.

Rye is quite an important crop in the county, and in acreage is second to barley. From 8,759 acres a yield of 134,178 bushels, or about 15 bushels per acre, was secured. This crop is grown more extensively on the sandy and loamy soils than on the clay loam.

Although the acreage devoted to wheat has been gradually decreasing for about 20 years, this crop is still being grown on

quite a number of farms, and in 1909 the yield amounted to over 80,000 bushels. The acreage of winter wheat was 1,686 and of spring wheat 3,546. The yield of spring wheat was 14 bushels and of winter wheat 16 bushels per acre.

From the standpoint of acreage the potato crop is next to that of wheat, and during 1909 the yield from 1,357 acres was 85,692 bushels, or an average of about 63 bushels per acre. Potatoes are grown in all parts of the area and on nearly all of the soils. The sandy loam and loam types are better adapted to the crop than the heavy clay loam. They are grown chiefly for home use, and the industry has not developed to any extent on a commercial scale.

The acreage devoted to corn is smaller than that devoted to any of the other general farm crops. Only 781 acres were reported for 1909 and the yield was 22,438 bushels, or an average of about 28 bushels per acre. The great difficulty in the production of corn is the short season and the cool nights. One factor which often delays planting in the spring is the poorly drained condition of the fields. The ground being wet and cold, the seeds germinate slowly if at all. By tile drainage the temperature of the soil could be increased considerably and cultivation and planting begun earlier than on the undrained, cold land, thus insuring success where failure would otherwise probably result. During the past few years considerable attention has been given to the breeding of varieties of corn which would be able to withstand the most severe climatic conditions in the State. A number of farmers in the county are growing these pure-bred varieties with considerable success under the direction of the Wisconsin Experiment Station.

In addition to the crops above mentioned, there is a small acreage devoted to buckwheat and flax. These crops, however, are of minor importance. Flax is "hard on the land" and is confined chiefly to a few low, poorly drained areas bordering marshes. It is not probable that the acreage of either crop will be extended.

Among the special crops grown in Kewaunee County peas is the most important. This industry was more extensive several years ago than at the present time. While canning factories are located at Algoma and Kewaunee, the output has been reduced and

some factories have gone out of business. Formerly the factory owners rented the land from the farmers and handled the crop, but in recent years the farmers have done all of the work, selling the peas to the factories for 1½ to 2½ cents per pound. A portion of the crop is allowed to mature. A factory at Kewaunee buys the ripe peas and shells, splits and cans them dry. They are sold chiefly to the U. S. Navy. In general it may be said that the yields are smaller now than formerly. The poorly drained condition of the land in many cases causes crop failure.

The production of sugar beets has not developed to a very great extent. More beets are grown on the Kewaunee loam than on other types. Yields range from 10 to 14 tons per acre and $6 per ton is the usual price secured. The farmers pay the factory $20 per acre for cleaning the beets.

The trucking industry has not been developed on a commercial scale in this area. Around the towns a small quantity of truck is grown to supply the local markets, and home gardens are made on all of the farms of the region, but aside from these no effort is made to develop trucking. The growing of truck crops, strawberries, etc., could well be carried on to a greater extent on the lighter soils of the area, especially where these soils are convenient to shipping points.

On a large number of the farms small apple orchards are found and the fruit appears to do fairly well, although the industry has not been developed on a commercial basis. Kewaunee County lies within the portion of the State considered to be adapted to the growing of fruit, especially apples and cherries, and some orchards are now being put out in the country north of Algoma. There are numerous good orchard sites in the area, climatic conditions are favorable, and suitable soils can be selected. It would seem, therefore, that the industry could be profitably extended if proper care is exercised in selecting varieties, planting, cultivating, etc.[1]

Dairying is the most important industry followed in Kewaunee County. The product is sold chiefly in the form of cheese and butter, and cheese factories and creameries are to be found in all

[1] See Bul. 201, University of Wisconsin Agricultural Experiment Station, on "Planting the Commercial Orchard."

parts of the county. In 1905 there were but 5 creameries in the county, while in 1910 the number had increased to 10. The output of butter for 1909 was 331,781 pounds, which was an increase of about 8 per cent over the production of 1905. The manufacturing of cheese is much more extensively developed. In 1905 there were 61 cheese factories in the county. In 1910 there were 63 factories, which produced 3,991,803 pounds of cheese, an increase of about 32 per cent over the output for 1905. In 1910 there were 17,288 dairy cows in Kewaunee County, or about 54 milch cows per 100 head of cattle. By far the greater part of the dairy stock is of mixed breeding and many of the animals would be classed as scrub stock. The type is gradually being improved, chiefly by the use of pure-bred Holstein and Guernsey sires, but this should be carried on to a greater extent than at present. There are some pure-bred cows in the county, but the number is comparatively small. While silos are used to some extent, their use is not nearly as common as it should be in a dairy country. The number of silos is gradually increasing and the dairy industry is being extended each year.

The raising of beef cattle receives but little attention in the county. But few farmers make a specialty of the beef breeds, and the stock sold for slaughtering consists chiefly of mixed breeds, which do not conform to any particular type. The horses of the area show more careful breeding than do the cattle. Heavy draft horses are common, and many farmers raise one or more colts each year and frequently have a team to sell, aside from keeping the farm supplied with good work animals. There are about 9,800 sheep in the county, but the raising of sheep is not developed to any extent in any one section. Those kept are scattered throughout the county, and no one farmer ever owns a large flock. Hog raising is carried on in conjunction with dairying. Practically all farmers raise enough pork for their own use and many have a number of hogs to sell each year. Poland China, Berkshire, Duroc Jersey, and Chester Whites were seen, though most of the hogs are of mixed breeding.

The general farm crops common to this region are grown upon nearly all of the soils in the county. The predominant soil is the Superior clay loam, and many farms are made up entirely of this

type. The texture of the soil can not be changed, and but little effort is made to determine whether the crops now grown are those best adapted to prevailing conditions or whether there may be other crops which could be grown more profitably. The question of the adaptation of soils to crops has received but comparatively little attention in the region covered by the present survey.

The question of crop rotation is also one which has not been carefully studied by many of the farmers, and about the same rotations are followed on nearly all of the soils, regardless of how well these may be suited to prevailing conditions. The rotation most commonly used consists of corn or peas one year, followed by one or two years of small grain, consisting of oats, barley, wheat, or rye. Clover and timothy mixed are seeded with the grain and hay is cut for one or two years. The field may be pastured for a year before plowing for corn or peas.

In many cases the methods of cultivation followed are not those best suited to the needs of the soil. This is especially true of the Superior clay loam. Poor drainage conditions keep the soil wet until late in the spring, and it often happens that the fields are cultivated before the soil is dry enough to work up properly. A puddled condition sometimes results, and considerable time and labor are required before the field is again in good tilth. Fall plowing, especially on the heavier soils, is quite common, and it is a good practice to follow, since the freezing and thawing breaks up the lumps, kills many weed seeds, and makes the soil more retentive of moisture. Stable manure is the only fertilizer in common use in the county. The plowing under of green crops is not practiced to any extent, nor are commercial fertilizers used.

While there are a number of troublesome weeds in Kewaunee County, there are two which are particularly noxious—quack grass and Canada thistle.[1] These weeds are extremely difficult to eradicate because of their peculiar nature and habits. Many fields are more than half overgrown with one or both of these, and crop yields are sometimes materially reduced because of their

[1] See Circular No. 48 of Agricultural Experiment Station of the University of Wisconsin on "How to Rid Our Farms of Weeds." This describes the habits and life history of numerous weeds, and gives directions for their eradication.

presence. A concerted effort should be made by the farmers of the county to rid themselves of these pests before more serious conditions develop.

In general, it may be said that the farm buildings and farm improvements throughout the county are good. The most marked exceptions to this occur on the more poorly drained portions of the Superior clay loam and on the gravelly and very sandy soils. Farm machinery is sometimes allowed to remain unprotected because of lack of suitable storage room, and in some sections the repairing of buildings is delayed until a shiftless appearance develops. However, the majority of the farmsteads present a neat, thrifty appearance, which usually indicates a prosperous condition of the farmer. The problem of securing labor on the farms is not as difficult of solution in Kewaunee County as in many other sections of the State. As a rule, the farms are small and the families are able to handle all of the work without being compelled to hire help. It is very common to see women and children working in the fields. Where the farms are larger and additional labor is necessary the wages range from $25 to $30 per month, and in a few cases even more. Where extra help is needed during haying and harvest time from $1.25 to $1.75 per day is paid.

The farms in the county were free from mortgage debt. The average value of all farms in the county in 1900 was $22.64 per acre. In 1910 the average value had risen to $52.20 per acre. Farm values vary greatly with the character of the soil and the improvements, ranging from as low as $8 to $10 an acre on the poorest soils to $100 to $125 an acre, and even more where highly improved, on the best soils.

One of the greatest needs of the county as a whole is drainage. The Superior clay loam in particular requires tile drains. Parts of the rolling phase would also be improved by tiling. The land is cold and wet in the spring and planting is often delayed. Over portions of many fields, especially where the surface is undulating or level, crops are a total failure because of the excess of moisture. The installation of tile drains would be a good investment and the owners of such land should not delay making such improvements. If only three-fourths of a field is producing

good yields the loss of the one-fourth may mean the difference between financial success and failure for the year. On high-priced land it is poor economy to allow any portion of the farm to be unproductive of maximum crops.

The growing of green manuring crops to be plowed under could well be practiced to a greater extent for the purpose of supplementing the stable manure. If clover were to be seeded without a nurse crop on well-drained land there would probably be less difficulty in securing a good stand. Clover is better for a green manuring crop than any of the other crops now grown in the county.

The questions of crop adaptation and rotation should receive careful study. These matters have been treated more extensively under the description of the various soil types.

CHAPTER VIII.

CLIMATE.*

"Among the factors which influence the agriculture of a state, none is more important than the climate. The class of crops which can be grown is largely determined by the length of the growing season, and the amount and distribution of the rainfall." Any one of these factors may determine the type of agriculture which can be practiced to best advantage.

"The distribution of the rainfall over Wisconsin is remarkably uniform, the average yearly precipitation having a range of from about 28 to 34 inches, while the mean for the State as a whole is 31 inches. This is a slightly heavier rainfall than is received by eastern England, northern France, most of Ger- portions of this country, Wisconsin has a total rainfall equaling that of central Oklahoma and Kansas, northern Iowa, Michigan, northwestern New York, or the Puget Sound Basin of Washington. But owing to its northerly location the lessened evaporation probably makes the precipitation as effective as that of Arkansas, Illinois, or Virginia".

"The local distribution of rainfall varies, however, from year to year, some sections receiving more rainfall one year, and other sections more in other years. The variation is caused by the movement of cyclonic storms." The average rainfall for the entire State during the driest year was 21.4 inches and for the wettest year 37 inches.

"Of equal importance in agriculture, to the total rainfall, is its seasonal distribution, and in this respect Wisconsin is un-

* This chapter has been based largely upon, and the quotations indicated have been taken from, Wisconsin Bulletin 223 on "The Climate of Wisconsin and Its Relation to Agriculture." This bulletin should be consulted for more information on the subject.

usually fortunate, since about half of the total rainfall comes in May, June, July, and August, and nearly 70 per cent from April to September, inclusive. June has the heaviest rainfall, averaging 4.1 inches, while July averages 4 inches and May 3.9 inches. The precipitation during the winter, on the other hand, is slight; December, January, and February each averaging from 1 to 1.5 inches of rain and melted snow. The average rainfall for the State during winter is 3.9 inches, during spring 8.3 inches, during summer 11.4 inches, and during autumn 7.4 inches.'' Most of the rainfall occurs just preceding and during the period of plant growth, thus being received by the crop at the most effective time. ''Wisconsin receives during the growing season, April to September, inclusive, an average of 21 inches of precipitation, which is as much rain as that received during the same months by eastern Texas, Illinois, Ohio, or eastern New York. The small winter precipitation in Wisconsin, mostly in the form of snow, on the other hand, causes virtually no leaching of fertility from the soil, or erosion.''

Another phase of rainfall distribution of great importance is its variation within a period of a few weeks. Frequently periods of drought and periods of unusually heavy rainfall occur, continuing for one to four weeks, or occasionally longer. Observations taken at Madison by the Weather Bureau over a period of 30 years from 1882 to 1911, inclusive, show that there are on the average three ten-day periods during each growing season when the amount of rainfall is so slight that crops on a reasonably heavy soil (Miami silt loam) actually suffer from the lack of moisture. In Kewaunee County where most of the soils are heavy in texture the same conditions would prevail.

Kewaunee County is located entirely within ''The Michigan Shore'', which is one of eight climatic provinces in Wisconsin. ''This section possesses the most equable climate in Wisconsin. The winters are mild, (22°) and somewhat moister than elsewhere in the State, resembling those of the coast of Maine, or eastern Michigan; the springs (42°) are retarded and cool, like those along the coasts of New England and British Columbia; the summers (67°) are mild and pleasant, averaging over 2° cooler than the Wisconsin or Rock River valleys and 4° cooler

than the Mississippi Valley; while the autumns (50°) are warmer than further west, the temperature being about the same as that of eastern Massachusetts, the Hudson Valley, or the Lake Ontario shore of New York. During the winters an average of five days shows a temperature lower than 10° below zero, while on seven days in the year the thermometer registers 90° or more. The lake shore is not a distinctive corn region, but is splendid for pasture, peas, and hay, the growing season extending from about May 1 to October 10, thus resembling southern Ontario and northwestern New York. The average rainfall (30.3 inches) is slightly less than that of the State in general, and a larger proportion is precipitated in winter (5.2 inches), and less in summer (9.6 inches)."

By reference to figures — and —, it will be observed that the average date of the last killing frost in the spring in Kewaunee County is between May 10 and 20, and that the first killing frost in the fall occurs between about October 1 and October 20. This would indicate that the average growing season extends over a period of about 147 days. From the data given on these two maps the approximate length of the growing season in any portion of the State can be determined.

No long-established weather records are available for Kewaunee County, and no records at all are available showing the differences in temperature between the country along the lake shore and the region from 2 or 3 to 15 miles inland. The records taken at Green Bay and Manitowoc will apply better to Kewaunee County than any other records available, and they are therefore given in the tables below. Manitowoc is situated on the shore of Lake Michigan, only 16 miles south of the southern boundary of the area surveyed. The elevation of the station is 616 feet above sea level, or about 38 feet above the level of the lake. The station at Manitowoc is considerably lower than the general elevation of the upland country along the Lake shore. For example, six elevations taken in West Kewaunee Township and reported by Chamberlin show the upland country to range from 124 to 145 feet above the lake. The valley of the Kewaunee River includes practically all of the land in the county whose elevation is less than 50 feet above the lake, and this land covers an ex-

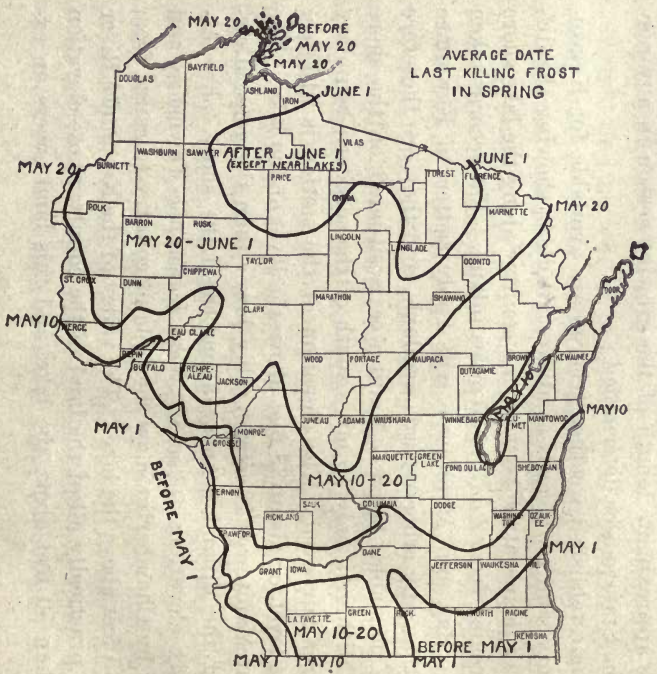

FIG. 3. LAST KILLING SPRING FROST.

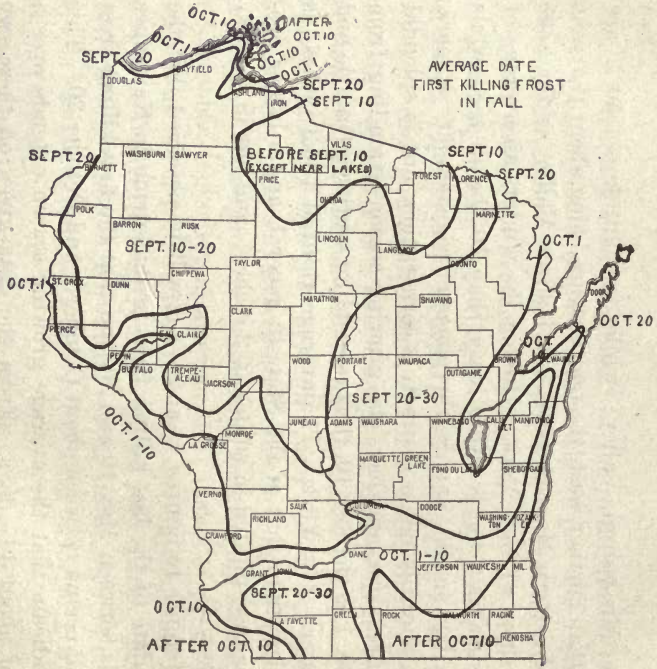

FIG. 4. FIRST KILLING FALL FROST.

These maps have been prepared from the original monthly reports of the observers of the U. S. Weather Bureau for the past 12 years, supplemented by private records.

tremely small area. It is not definitely known what difference in the climatic conditions this range in elevation would show. Green Bay is 617 feet above sea level, or about 39 feet above the level of Lake Michigan. This station is also lower by perhaps 100 feet than the country along the western border of the county, although Green Bay City is but 13 miles west of the western boundary line of the survey.

Normal monthly, seasonal, and annual temperature and precipitation at Manitowoc.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	° F.	° F.	° F.	Inches.	Inches.	Inches.	Inches.
December ...	24	60	—21	1.7	1.5	5.5	7.0
January	18	51	—32	1.7	1.6	0.7	8.5
February ...	18	56	—29	1.5	0.5	2.3	7.7
Winter	20	.....	.....	4.9	3.6	8.5	23.2
March	28	70	—13	2.0	0.4	1.6	6.0
April	42	85	8	2.5	1.5	4.3	2.3
May	52	92	18	2.6	4.4	2.4	0.2
Spring	41	.....	.....	7.2	6.3	8.3	8.5
June	62	97	33	3.4	1.5	5.2	0.0
July	67	100	38	3.7	1.8	5.4	0.0
August	66	99	39	3.1	3.5	4.8	0.0
Summer ..	65	.....	.....	10.2	6.8	15.4	0.0
September ..	59	96	26	3.0	1.2	1.6	0.0
October	48	84	11	2.6	0.5	5.0	0.4
November ...	34	69	—10	2.1	2.2	1.8	3.8
Fall	47	.....	.....	7.7	3.9	8.4	4.2
Year	43	100	—32	30.0	20.6	40.6	35.9

Normal monthly, seasonal, and annual temperature and precipitation at Green Bay.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	° F.	° F.	° F.	Inches.	Inches.	Inches.	Inches.
December	22	51	—21	1.8	1.8	3.8	10.7
January	16	51	—36	1.8	2.0	3.3	14.4
February	17	59	—33	1.7	0.7	3.2	13.5
Winter	18	.....	.....	5.3	4.5	10.3	38.6
March	28	72	—23	2.3	0.4	1.9	9.0
April	44	84	—11	2.5	1.2	2.8	2.1
May	55	91	29	3.3	4.3	3.1	2.5
Spring	42	.....	.....	8.1	5.9	7.8	13.6
June	66	96	34	3.6	3.4	5.2	0.0
July	70	99	44	3.4	1.4	4.5	0.0
August	68	98	41	2.7	3.7	4.6	0.0
Summer	68	.....	.....	9.7	7.5	14.3	0.0
September	60	95	25	3.3	1.2	1.8	0.0
October	48	84	8	2.6	0.4	3.6	0.0
November	33	69	—12	2.0	1.5	1.7	7.0
Fall	47	.....	.....	7.9	3.1	7.1	7.0
Year	44	99	—36	31.0	21.0	39.5	59.2

Station.	Length of record in years.	Average date of—		Date of—	
		First killing frost in autumn.	Last killing frost in spring.	Earliest killing frost in autumn.	Latest killing frost in spring.
Manitowoc	47	Oct. 10	May 9	Sept. 24	May 31
Green Bay	23	Oct. 2	May 3	Sept. 16	May 30

From these tables it will be seen that the average annual rainfall of the region surveyed is about 30 inches, the greater part of which comes during the growing season, when most needed; and that during each of the six months from April to September there is a rainfall of not less than 2.5 inches. There are times during nearly every season, however, when crops suffer from lack of moisture. While the average rainfall at Manitowoc is 30 inches, it may vary from about 20 to 40 inches. The average snowfall at Manitowoc is 39.9 inches. The winters are long and severe and the summers are, as a rule, cool and pleasant. The mean annual temperature at Manitowoc is 43° F. and at Green Bay 44° F. The table showing frost data indicates that the region has an average growing season of 150 to 160 days. From 145 to 150 days, however, would probably be nearer the average for Kewaunee County alone.

The influence of the Lake tends to maintain a more uniform temperature than is found in regions more remote from large bodies of water. The climatic conditions over the county are favorable to the production of fruit when the proper locations and soils are selected. Immediately along the shore of the Lake the temperature is usually somewhat lower than it is several miles back, the coolness of the nights being particularly noticeable. Corn can be more readily matured several miles inland than immediately along the Lake shore.

SUMMARY

Kewaunee County is located on Lake Michigan in the eastern part of the State and comprises an area of 341 square miles of 218,240 acres.

The surface of the area varies from level to rough and the most pronounced feature is the Kettle Moraine, which begins near the center of Casco Township and extends southward. The bluffs along the lake range from 50 to 100 feet in elevation and the highest points in the county are over 150 feet above the lake level. With the exception of a small area in the northeastern part of the county, the drainage is into Lake Michigan, chiefly through the Kewaunee River and its tributaries.

The county was organized in 1856 and agricultural development began about that time. Kewaunee and Algoma are the chief towns. The area is traversed by the Kewaunee, Green Bay & Western Railroad and a branch line called the Ahnapee & Western.

There are 20 soil types in Kewaunee County, although a number of these are of small extent and of little importance.

The Superior clay loam, including the rolling phase, constitutes by far the most extensive and important soil in the county. It occurs as a belt along the lake shore and is also extensively found in the western part of the county. Where the surface is flat and the natural drainage deficient the soil has been mapped as typical Superior clay loam, but where the surface is sufficiently rolling to insure fair to good surface drainage the soil has been mapped as the rolling phase of the Superior clay loam.

The Superior loam, rolling phase, is an important type in the northern part of the county, where it is closely associated with the Superior clay loam, rolling phase. It is a good soil and most

of it is cultivated. General farming and dairying are the main agricultural pursuits.

Superior fine sandy loam, rolling phase, is of small extent, but most of the type is under cultivation and devoted to general farming. It is better adapted, however, to truck and small fruits.

The Miami loam is a widely developed type in the county and constitutes a fair general farming soil. The dairying industry should be extended over this type.

The Rodman gravelly loam resembles the Miami loam, except that it contains a large quantity of gravel, is underlain by stratified material, and frequently has bowlders upon the surface. It is not an extensive type and occurs in widely distributed areas. But little of the type is cultivated, and where timbered it should be kept in forest.

The Rodman gravelly sandy loam is of small extent. Very little of this soil has ever been cultivated and crop yields are low. Most of the type is non-agricultural, and in general it is best suited to grazing and forestry.

The Rodman gravel has practically no agricultural value and occupies only a few small areas. It would be useless to attempt its cultivation, and it should be kept in timber.

The Rodman sandy loam is not widely developed, but covers a larger area than the gravel or gravelly loam types. It is easy to cultivate and responds readily to fertilization and careful treatment. Most of the type is cultivated and fair yields are secured. The methods of farming should be improved.

The Rodman fine sand is of small extent and little importance. It could be improved by the addition of organic matter. The type is better suited to early truck crops than to general farming.

The Fox silt loam is a good general farming soil, and practically all of the type is under cultivation. The corn crop should receive greater attention, and alfalfa should be more extensively grown. Dairying constitutes the most promising industry. The type is somewhat deficient in organic matter.

The Fox sandy loam is of very limited extent and of minor importance from an agricultural standpoint. Most of it is under cultivation and devoted to general farming.

Plainfield gravelly sandy loam and sand are also of limited extent and of little importance. The texture is rather coarse, the structure loose and open and a droughty condition prevails during a part of each growing season. The agricultural value of both types is low.

The Poygan silt loam is a strong soil, yet this soil and the Poygan sand are so inextensive as to be of little agricultural importance.

The Genesee loam and fine sandy loam types comprise a small total area and occupy the bottom lands along the chief streams of the county. The former type affords good pasturage and little of it is cultivated, while the greater part of the latter is cultivated, good yields of the crops common to the region being secured.

The Clyde silt loam is fairly extensive and occupies low-lying areas where there has been an accumulation of vegetable matter, but not in sufficient quantities to form Muck or Peat. A small part of the type has been cleared and is used for pasture. It is naturally a rich soil, but needs drainage. If reclaimed, this would become a strong and valuable soil.

None of the Peat lands of Kewaunee County have been reclaimed, although they are comparatively extensive, and by careful drainage and proper cultivation could be made to produce profitable crops.

The type of agriculture followed at present consists of general farming, with dairying as the most extensively developed branch. There are 63 cheese factories and 10 creameries in the county and the output from these is gradually increasing. The dairy stock is mostly of mixed breeding, but is being improved by the use of pure-bred sires. The general farm crops grown consist of oats, barley, rye, hay, wheat, and corn, with smaller acreages of potatoes, sugar beets, peas, and a little flax. The growing of fruit and truck crops has not developed to any extent. The most common rotation followed consists of corn or peas, followed by oats, barley, rye, or wheat for one or two years. Clover and timothy are seeded with the grain, and hay is cut for one or two years. The fields may be pastured for a season. Fall plowing is quite common, especially on the heavy soils which are likely to be wet and backward in the spring. The Superior clay loam is

the most difficult to cultivate of the various types in the county. Many parts of the county are in need of tile drainage, and this is one of the most serious problems in the region. The most noxious weeds are quack grass and Canada thistle, and many farms are badly infested with these pests.

The average rainfall for this region is about 30 inches and the mean annual temperature 43° F. There is an average growing season of from about 145 to 150 days free from killing frost. The winters are long and severe and the summers cool and pleasant. The summer nights are usually cool, which retards the rapid growth of corn and makes it more difficult to mature than in some sections where the growing season is shorter but the nights warmer.

KEEP THE MAP.

The Experiment Station will publish bulletins from time to time dealing with the management of the different types mapped, so that some way should be found by each person receiving a copy of this report to keep the map permanently. If the map is folded in such a way as to have the part you are interested in of a convenient size, and then have a simple frame with glass made to hold it, it can be kept indefinitely. Since some of the colors fade after being exposed to strong light for a long time, it would be a good plan to have a protecting flap of dark cloth over the map when not in use.